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Operational Characteristics of Rear Projection

By JOHN F. DREYER

Rear-projection screens of low reflection reduce the effects of light on the screen and allow increase in the ambient light. Goniophotometric curves and setup of screen are given. Distribution, gain, reflection and resolution are discussed as factors. The physiological effects of increased ambient light are considered. The brightness of the picture should at least equal the level of the surrounding light to which the eye is adapted.

In any projection system there is an interrelationship between the projector, the film, the screen and the viewing conditions. By using a rear-projection or transmission-type screen, the elements of the projection system can be varied to provide the best viewing conditions. Rear-projection screens of the latest-type are made up of millions of tiny lenses imbedded in a plastic. The light by reflection and refraction is diffused by the lenses as it passes through the screen. The proper selection and combination of materials result in screens that give very low front reflection along with high transmission. These rear-projection screens provide maximum performance over a wide range of lighting and viewing conditions.

The four primary optical characteristics of a screen are distribution, gain, reflection and resolution. The secondary characteristics of color, uniformity and stability are easily controlled in a rear-projection screen. Therefore only the operational characteristics of rear projection in the light of the primary areas are discussed here.

Distribution and Gain

Light distribution is one of the most important characteristics of a screen. It is a measure of the light-spreading character of the screen. It is a determining factor in the usable width of the screen, the permissible focal length of the projector and the projector wattage required.

Distribution is given as a plot which shows the intensity of a ray of light at the different angles to which the light is bent by the screen. The curve is obtained by measuring the brightness of a narrow parallel beam of light as it is spread out by the screen. The characteristic curves of light distribution are made with a light-measuring goniophotometer.[1] The curves obtained from the instrument are plotted on a log scale related to magnesium carbonate at 100%.

Figure 1 shows the characteristic curves on a log plot for a screen with a gain of 500%. A gain of 500% indicates that the picture is five times as bright (normal to the screen) as for a matte-type reflection screen having a value of 100%. From an angle of about 28° to the screen and on out, the brightness falls below that of the matte screen.

Rear-projection screens are made with different light-distribution curves to conform to various use requirements. Figure 2 shows a distribution curve for a gain of 250% with a flatter curve. Projection screens are viewed at a limited angle. When the angle of view is beyond 40° from the centerline of the screen, a foreshortening effect of perspective occurs which distorts the picture excessively and it is not generally desirable to consider angles beyond this 40°. It is generally desirable to place as much light as possible uniformly throughout the viewing angle. If the light distribution make-up of the screen is not uniform enough, undeviated light concentrates to make a hot spot. The gain for a rear-projection screen is related to a perfect front-reflecting diffuser, the same as for front-reflection screens.

The distribution curve is often misused. It has been erroneously suggested that an ideal rear-projection screen would diffuse all the light through an angle of 30° from the normal to the screen, no light being diffused beyond that angle. This concept is based on the assumption that the viewing angle is the same at 30° each side of the normal to the screen. This concept is an erroneous simplification of the conditions. Figure 3 shows two rear-projection setups. Let us consider first the system on the righthand side (System 1).

The projector in System 1 has a throw of five times the screen width. The viewing audience is positioned along the line *A–E*, placed twice the screen width away from the screen. Light emanating from the right side of the projector along the line *HG* must be deflected by the screen at point *G* to points *GA*, *GB*, *GC* and *GD*. From the left side of the projector along the line *HF*, deflection must be made to points *FA*, *FB*, *FC* and *FD*. At point *A* the projector light is deflected in the amount of the angles *AFB* and *AGI*. At point *B* the deflection angles are *BFB* or zero, and *BGI* on the right.

The deflection-angle ranges for the various viewing positions shown in Figure 3 are given in Table I. The maximum difference of 36° in deflection of the light from the projector occurs at point *B*. Moving the audience to a position farther away from the screen will result in a narrower angle of deflection and the deflection will be less than the values shown in the table. At point *D*, which is at an angle of 30° with the normal at the near edge of the screen, the deflection is as much as 52° in the angle *DGI*. Consequently, it should not

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(Paper first received on May 14, 1959, and in its present form on July 15, 1959.)

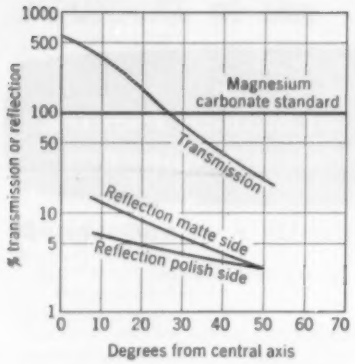

Fig. 1. Characteristic curves on a log plot for a screen with a gain of 500% (Lenscreen LS75G, glass).

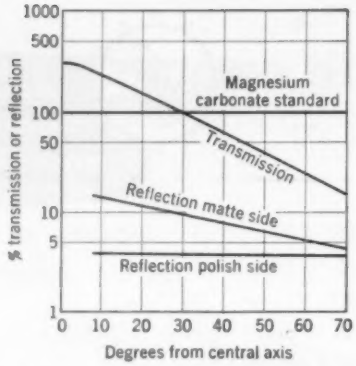

Fig. 2. Distribution curve for a gain of 250% with a flatter curve (Lenscreen LS60G, glass).

be thought that a 30° position requires only a 30° deflection.

On the left side of Fig. 3 is a rear-projection setup marked System 2, which is identical to System 1 except that a projector lens having a shorter focal length is used, resulting in a projector throw of 1½ times the screen width. The same calculations have been made for System 2 as for System 1. The corresponding angles are now much larger than for System 1. The screen must deflect the light at greater angles for a short focal length lens than for a long focal length lens. The position along the extremes of the projector line again has the greatest difference in deflection angle.

By using the angles given in Table I and applying them to the distribution curve of Fig. 4, for the Flexible screen, the values in Table II are obtained. These values represent transmission at the various angles. By dividing the per cent of light transmission for the minimum deflection angle with that of the maximum deflection angle, a light intensity ratio is obtained which is shown in the fourth column of this table. This value is a ratio of the intensity range of the transmitted light for a given viewing position. The values given are based on an ideally uniform distribution of light by the projector, which is never the case in practice.

The intensity ratios given in this column are arithmetical ratios of the light energy for this particular screen (the LS60F) under the given conditions. One very important factor, the sensitivity of the eye is not taken into consideration. Fechner's Law states that as the stimulus to the eye is increased in *geometrical* progression, the resulting sensation is increased in *arithmetical* progression. The contrast sensitivity then varies directly as the logarithm of the stimulus.[2]

If the transmission at 100% is assumed to be at the point where the projector intensity is 10 ft-L, the light intensity can be expressed in terms of a logarithmic value. An eye-sensitivity brightness ratio can then be obtained from the maximum and minimum values which are the logarithms of the transmissions at the extreme angles on the screen. This logarithmic brightness ratio is a measure of how the eye actually sees the light and is a value of merit, whereas the arithmetical ratio is simply an energy ratio. As Table II shows, the arithmetical intensity ratio *increased* from positions *C* to *D* while the logarithmic brightness ratio *decreased* from the same movement.

Furthermore, as the projector intensity is increased, the screen brightness becomes more uniform. This is shown in the Table by assuming a projector intensity of 100 ft-L. The uniformity of the brightness of a screen is increased with a greater amount of light. This can be demonstrated by increasing the intensity of light of the projector. An apparent spreading out of the light from the center to the edges will be seen, rather than a simple uniform increase in light intensity.

Experience is being accumulated on what is an acceptable eye brightness ratio for various conditions. This value, however, may vary with the size of the screen and the surrounding light level. The projector throw distance should preferably be at least three times the screen width. For small screens, the throw distance should be not less than 1½ times the screen width.

The same calculations and limitations

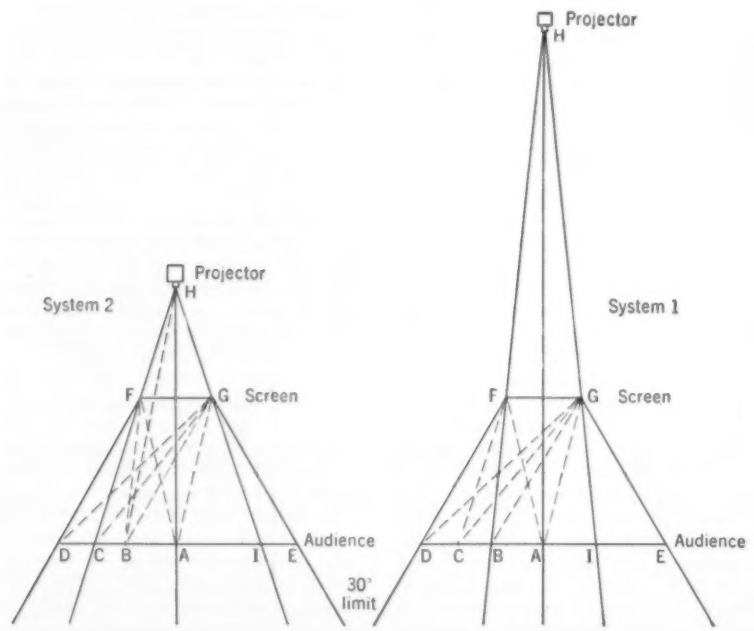

Fig. 3. Two rear-projection setups—System 2 shows corresponding angles much larger than for System 1.

Table I. Deflection Angle Ranges for the Various Viewing Positions Shown in Figure 3.

Viewing position	Deflection, degrees	Max. difference, degrees
	System 1	
A	20 to 0 to 20	20
B	0 to 36	36
C	12 to 44	32
D	24 to 52	28
	System 2	
A	32 to 0 to 32	32
B	5 to 0 to 49	49
C	0 to 68	68
D	13 to 77	64

Table II. Variation of Intensity and Brightness Ratio.

Viewing position	Deflection angle range, degrees	% Transmission from curve LS60F	Intensity ratio	Log of intensity at 10 ft-L = 100%	Brightness ratio	Log of intensity at 100 ft-L = 100%	Brightness ratio
			System 1				
A	0 to 20	215 to 112	0.52	1.33 to 1.05	0.79	2.33 to 2.05	0.88
B	0 to 36	215 to 57	0.27	1.33 to 0.76	0.57	2.33 to 1.76	0.75
C	12 to 44	152 to 40	0.26	1.18 to 0.60	0.51	2.18 to 1.60	0.74
D	24 to 52	97 to 28	0.29	0.99 to 0.45	0.45	1.99 to 1.45	0.73
			System 2				
A	0 to 32	215 to 68	0.32	1.33 to 0.83	0.62	2.33 to 1.83	0.79
B	0 to 49	215 to 32	0.15	1.33 to 0.50	0.38	2.33 to 1.51	0.65
C	0 to 68	215 to 13	0.06	1.33 to 0.11	0.09	2.33 to 1.11	0.48
D	13 to 77	147 to 8.4	0.06	1.17 to 0.09	0.08	2.17 to 0.92	0.43

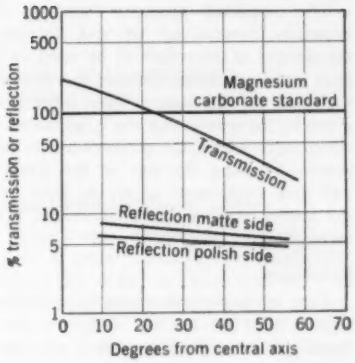

Fig. 4. Distribution curves of reflection characteristics of a screen (Lenscreen LS60F, flexible). Front reflection is shown in the lower part of the figure.

as those shown in Fig. 3 apply to front-projection systems. The distribution curve for the LS60F Lenscreen used in the calculations is close to that of a pearl, or low-gain, aluminum screen. At present there are available no rear-projection screens with a flat distribution curve exactly like that of the matte white reflecting screens.

In practical application the distribution required for a particular screen depends upon a number of factors. The distance of the projector from the screen is important. Table I and Fig. 3 show that the farther away the projector, the less the screen has to divert the light. This distance is limited by the lens and the space available for a given picture size. The size of the picture is related to the type of information to be presented and to the area in which the audience will view the picture. The audience area is most critical as to closeness to the screen and sideways spread. It has been found that the audience area for rear projection can extend farther back from the screen than for front projection. The screen size is also related to the amount of projector light available, the level of the ambient light and the density of the pictures to be shown.

For example, a microscope projector to be viewed by only one person positioned directly in front of the screen will make use of a narrow-angle distribution, high-gain screen. This type of screen gets the maximum use out of a limited amount of light. On the other hand, a compact sales-demonstration unit with a short focal length projector and a widely spread audience requires a wide-angle screen.

Reflection

The reflection characteristics of a screen are very important. With front projection, as high a reflection as possible is desirable, while with rear projection as low a reflection as possible is desired, as long as it does not reduce the screen's transmission. Reducing the reflection of the front surface permits an increase in the ambient light level and makes projection of pictures possible in well-lighted areas. For a screen to give good contrast in a well-lighted room without an excessively bright projector, it must have low reflection.

The curves of the front reflection are shown in the lower part of the distribution curves in Figs. 1, 2 and 4.

Screens are made with one side polished and one side a matte finish. The reflection curve is different for each side of the screen and two reflection curves are given in the figures, since either side may be used forward. When used with the screen's polished side toward the audience, the picture is sharper and has more contrast than with the matte side forward. However, bright lights spectrally reflected by the shiny surface are a disturbing factor. To prevent this reflection from being seen, the lights should be above or to the side but not in back of the audience. Under lighting conditions where bright reflection is disturbing, the screen may be tilted slightly or the matte side used forward. Either of these expedients will eliminate undesirable spectral reflections.

It has been established that for viewing pictures on a front-projection screen, the stray light should not be greater than 0.3% of the screen brightness.[3] This relationship does not hold true for a rear-projection screen, for as the level of ambient light is raised, the eye loses its high sensitivity to a small amount of light. Fechner's Law again is effective. Perhaps the best understanding of the relationship can be obtained by considering that the light reflected by the printed black ink of the SMPTE *Journal* is approximately 9% of the reflection of the white paper, which is an acceptable per cent for viewing under normal illumination. In the same way, a higher percentage of stray light can be tolerated when viewing a screen in normal illumination.

A low-reflection screen performs two important functions. It keeps the ambient light reflections to a minimum and allows the projector light to go through the screen.

For the projection screen to give low light loss, the rear reflection must be low.

To give good contrast, not only should the surface reflection be low, but also the area in back of the screen must be kept dark. This is very important. Room light passing through the screen must not be reflected by objects behind the screen and so light up the screen. The rear-projection screen allows the spectator to come outside the black box between the screen and the projector, but this area behind the screen must still be kept dark. The dark areas on the screen can remain dark only when there is no light shining on them from the back. The screen is critical to back-lighting.

It is common to use a mirror behind the screen to revert the image so that the film need not be reversed. This also acts to shorten the space required in back of the screen. The mirror is placed in line with the normal to the center of the screen to eliminate keystone effect. The projector line should be in line with the audience. A second surface mirror is generally satisfactory for this type of use.

There is a variation as great as 100 to 1 in the light intensity of various artificially lighted interiors. Outdoor lighting in daylight also varies as much as 100 to 1. The projector must give a picture which competes with the reflected ambient light under conditions where the eye has adjusted to the brightness of the area surrounding the screen.

The intensity of the light reflected by the area surrounding the screen is related to the intensity of the light and the reflectivity of that area.

With a rear-projection screen the screen should be placed where the surrounding area gives least reflection. It should face into the light. This is the reverse of what has been suggested for front-reflecting screens.

The required projector wattage is normally determined by five factors: the density of the prints to be used, the gain and light distribution of the screen, the size of the screen, the reflection given by the screen and the brightness of the area in which the pictures are to be shown. Halving the size of the screen will give four times as much light on the screen without having increased the wattage of the projector.

Resolution

The resolution characteristic of the screen is important for sharpness and detail. Rear-projection screens of Lenscreen type will give a definition of 60 lines/mm (measured directly on the screen with a microscope). This perfection is needed for small screens viewed from a short distance.

The conditions for viewing a rear-projection screen are no longer limited to a dark surrounding. Consequently, the effect of the surround now assumes a different role. We have all experienced the discomfort of going from a bright room into a dark area where a picture is being shown. Similarly, we have felt the discomfort of suddenly having the lights turned on after we have been accustomed to the dark. But further than this, there are physiological effects.

When a screen is being viewed in a normally lighted room, peripheral vision relates the screen picture to the entire room, whereas viewing the same screen under darkened conditions is a restriction that produces "tunnel vision." The physiological effect of rear projection viewed in normal light is a tying-in of the screen with the room, sometimes resulting in an apparent increase in screen size. This can be shown by turning the room lights off and on while viewing a rear-projection picture.

Studies have shown that visual acuity is greatest when the surrounding area brightness is close to that of the subject level.[4] Consequently, a rear-projection screen need not be as large as a front-projection screen to be readable. The optimum contrast and optimum screen brightness level requirements are not necessarily the same for a picture viewed in a lighted area as for a picture viewed in the dark. For example, a 20-ft-L screen may be too bright in the dark, but will be satisfactory in a well-lighted room.

The adaptation brightness of the eye is related to comfortable seeing.[5] If the eye has been adapted by the surroundings to a high level of brightness, then the picture should match that brightness. If a screen needs to attract attention, then it should be brighter than its surroundings.

In judging the contrast for rear projection, not only the brightness of the picture and the contrast of the negative should be taken into account, but also the per cent reflection of the front surface of the screen and the level of the surrounding brightness.

Proper use of the right type of low-reflection rear-projection screen will give the required dark areas in the picture, but the brightness of the picture must be up to the level to which the eye is adapted in order to appear bright. As a rule of thumb, the brightness of the picture at the angle to be viewed must at least equal the surrounding light.

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Discussion

Anon: For this rear-projection screen, how far back do you need the mirror?

Mr. Dreyer: With this particular combination it is back 4 ft 6 in. from the screen, the projector throw distance being 9 ft for this lens and screen size.

Synthetic Highs — An Experimental TV Bandwidth Reduction System

By W. F. SCHREIBER, C. F. KNAPP and N. D. KAY

A complete system is described which codes a standard video signal to match a narrower band channel and subsequently decodes the received signal for display on a standard TV monitor. The system transmits the low-frequency, or macrocontrast signal, in analog form. The location and amplitude of the edges are transmitted by a digital code. At the receiver the edge information is used to synthesize the highs content of the video, which is then added to the lows to reconstruct the original video signal. Bandwidth reduction is achieved by exploiting both statistical correlations and psychophysical phenomena.

Apparatus for the separation of low frequencies, detection of edges, quantization and binary digital coding of edge amplitude and synthetic reconstruction of highs is described. The digital coder for edge locations has been described elsewhere.[1] Picture-tube photographs of the resulting pictures are shown. Factors affecting the degree of bandwidth reduction and the effect of variation of system parameters such as separation frequency and quantization levels are discussed.

THE 4-megacycles/sec bandwidth required for the transmission of a standard video signal generally restricts picture transmission to the line-of-sight radio frequencies. Recent developments in the fields of tropospheric scatter and videotape recording have facilitated the handling of the 4-mc (megacycles/sec) bandwidth for certain applications, but the desirability of bandwidth reduction remains.

The noise-free transmission possibilities of digital systems are becoming increasingly important, but since straight 128-level or 7-bit PCM coding of a standard 4-mc video signal requires a channel capacity of 56×10^6 bits/sec or a binary channel bandwidth of 28 mc, some form of bandwidth reduction would appear to be essential.

The Nature of the Problem

The bandwidth necessary for a straightforward video signal is a function of the field rate, the number of lines per field and the detail required in each line. If degradation of the picture can be tolerated, then many solutions of the problem are possible,[2] depending on just how much and which kind of degradation is to be accepted. If, however, the entertainment value of the picture is to be unimpaired, then possible economical solutions to the problem are hard to come by — as is evidenced by the lack of working solutions in spite of the considerable effort in many quarters.[3]

There are in general two methods of coding by which the bandwidth may be reduced, namely, statistical and nonstatistical coding.[4]

Statistical coding makes use of the fact that, although a picture could contain a checkerboard pattern of about 250,000 elements requiring a 4-mc transmission bandwidth, pictures almost never contain such complex detail, and consequently transmission channels run idle or at low rates for a large proportion of the transmission time. To take advantage of this fact, it is necessary to store picture detail temporarily as it occurs and then read it out of storage at a slow and constant rate for transmission through a narrowband channel. In this way the channel capacity is set by the *average*, rather than the *peak* rate of information generation. The receiver must reconstruct the original video signal in real time. The main obstacle to such systems is the high speed (8 mc) of storage required. One such system using mainly cell-to-cell correlation has been instrumented by us[1] and will be described below. Systems using higher orders of correlation have been discussed,[5] but as far as we are aware, not instrumented.

The aim of nonstatistical coding is to modify the original video signal and to endow it with more favorable characteristics either for direct transmission[6] or for statistical coding. Any modification of the video signal must be such that in the final result the eye is unable to detect the change or is favorably impressed by it. At the very least, the eye should not find the changes too objectionable. This probably requires that for full exploitation of the eye's tolerance, we should know more about the characteristics of the eye than we do at present and also possibly more of the psychology of the viewer. However, some elementary facts are known and are in use.

Some Characteristics of Vision

The present system of 2:1 field interlace, in order to halve the bandwidth, makes use of the fact that the eye is less sensitive to microscopic than to macroscopic flicker. Efforts to improve on this by higher-order interlacing result in the illusion of lines crawling vertically in the picture.

As might be expected, the eye tolerates horizontal interlace about as well as vertical. When both are used together in an attempt to obtain a fourfold improvement, steps must be taken to avoid spurious effects. In the NTSC system, the horizontal interlace[7] is applied only to the chrominance information and hence is not usually very visible. We have constructed an experimental system using a 2-mc bandwidth with both horizontal and vertical interlace, with sample-holding to eliminate the dot-crawl effect. We found that the subjective resolution was equivalent roughly to a 3-mc picture and that there were no bad effects on motion continuity. It has been reported[8] that higher-order interlace than this again offends the eye.

Frame repetition using storage as an aid to frame-rate reduction has often been suggested. The results[9] indicate that frame repetition eliminates flicker while permitting some illusion of motion. Presumably, reduction to about 16 frames, the amateur motion-picture standard, should be acceptable. However, at frame rates of about 12 and less, small area motion, such as lip movements, suffers intolerable break-up, while panning shots result in the illusion of jerkiness. This occurs in spite of various methods of grouping and repeating the stored frames. It is possible that a better understanding of visual perception will lead to methods of grouping and repeating frames which the eye will regard with more tolerance. More such experiments are desirable, although the prospects are not promising. Thus we see that the present scanning standards already afford near-optimum exploitation of the properties of the eye, due regard having been paid to simplicity in receiver design. Further exploitation must depend upon operations on the video content of each line or on lines of the same or successive frames.

Another characteristic of vision that has been used in bandwidth reduction systems is that which renders the eye quite tolerant of large amplitude errors

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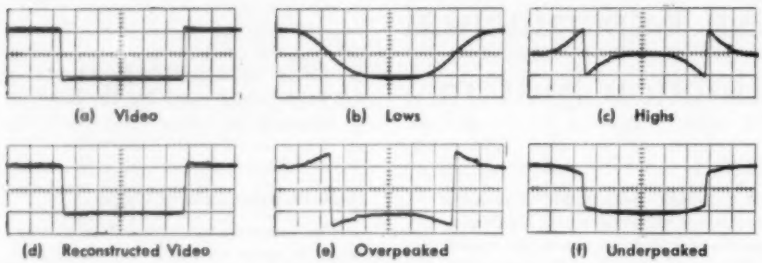


Fig. 1. Oscillograms of high- and low-frequency components of a square waveform, together with three reconstructed waveforms.

in high-gradient areas, although it can easily detect spurious contours in low-gradient areas due to too coarse a quantization. A tapered quantization exploits this fact, reducing the total number of levels (and therefore the bit rate) required.[10] However, this quantization is most profitably applied not to the video signal itself, but to a derived function, such as the difference signal in a delta-modulation system.[6]

There are undoubtedly many peculiarities of visual perception which have yet to be observed and exploited. The foregoing examples illustrate the variety of possibilities, and it is evident that a little ingenuity will probably reveal further characteristics of vision and appropriate schemes which will permit modification of video signal properties without causing objectionable picture distortion.

There are some methods of signal distortion which subjectively improve the final picture. The beneficial effect of one method[1] of "edge-peaking" has been described elsewhere, and audience reaction tests in our laboratories have indicated that most people actually prefer about 60% accentuation of the high-frequency content of a standard television picture. The desired percentage of overpeaking depends on the original picture quality and frequency band being emphasized.

The tolerance of the eye to exaggerated highs or edges is no doubt due to the fact that the eye itself has a built-in edge-peaking device[11] and consequently does not object seriously to small amounts of distortion which resemble its own peculiar type. G. M. Byram[11] concluded that under the most favorable conditions, vision is mainly a border or contour phenomenon. Observers from Helmholtz[12] to Evans[13] have gathered evidence, in the form of optical illusions, which supports this view. It is this phenomenon of visual perception which is used to advantage in the system of synthetic highs to be described.

Synthetic Highs System

The waveforms used for the overpeaking audience reaction tests are shown in Fig. 1 (a), (b), and (c). The highs waveform is obtained by subtracting from the video its own low-frequency content, obtained from a linear-phase low-pass filter. The highs waveform is seen to be mainly the edge detail of the picture. Conversely, the lows consist of the picture with all sharp edges removed. The lows bandwidth is about 350 kc, leaving about 3.65-mc bandwidth for the highs.

The signal separation thus far does not simplify the transmission problem, but examination of the highs waveform indicates an interesting possibility. The highs waveform retains the amplitude and rise time of each edge of the original video, but each edge now has leading and trailing portions which are shaped uniformly by the low-pass filter characteristic. If, therefore, the location and amplitude of the riser of each edge in the picture were known, it would be possible to synthesize the leading and trailing portions of the highs waveform to match the rise-and-fall time of the low-pass filter. Thus it would be possible to synthesize the highs waveform from a train of pulses carrying edge location and amplitude information only. The original video signal could then be reconstructed by adding the synthetic highs to the lows waveform. Reconstruction in this manner is illustrated by the oscillogram in Fig. 1(d). The effect of adding too much or too little of the synthetic highs is shown by the waveforms (e) and (f), respectively, of Fig. 1. As mentioned previously, the overpeaking of waveform Fig. 1(e) is preferred by most people to the original waveform Fig. 1(a).

This means that instead of transmitting the video signal directly it is possible to transmit the lows signal plus edge information to the receiver, which can then synthesize the highs waveform and reconstruct the original video. The synthesis of highs from edges is not merely novel, but actually offers an intermediate waveform which is particularly amenable to statistical digital coding as will be shown. That this is so may be seen by considering the specifications for the highs waveform. Firstly, it is important that the location of each edge be rendered accurately in order that successive lines may register. (The eye is particularly sensitive to kinks in nominally straight vertical lines.) Such accuracy requires that any practical coding of edge positions be digital rather than analog. Secondly, the amplitude of each edge may be rendered less accurately, provided only that small edges contain small errors and that large errors be confined to large-amplitude edges. This calls for tapered quantization of the edge amplitudes.

How this reconstruction is implemented is shown in Fig. 2. The edges in the picture may be detected by delaying the video signal by $\frac{1}{8}$ μsec and subtracting it from the undelayed video signal. Figure 2(c) illustrates the result of this operation, which is referred to as "edge-taking" for this system, although elsewhere it is referred to as cell-to-cell differencing or linear prediction. This waveform gives the location and amplitude of each edge.

If the edge pulses were put directly into the highs synthesizer, they would permit exact (both practically and theoretically) reproduction of the original highs. The amplitude is obtained directly from the edge signal, and the leading

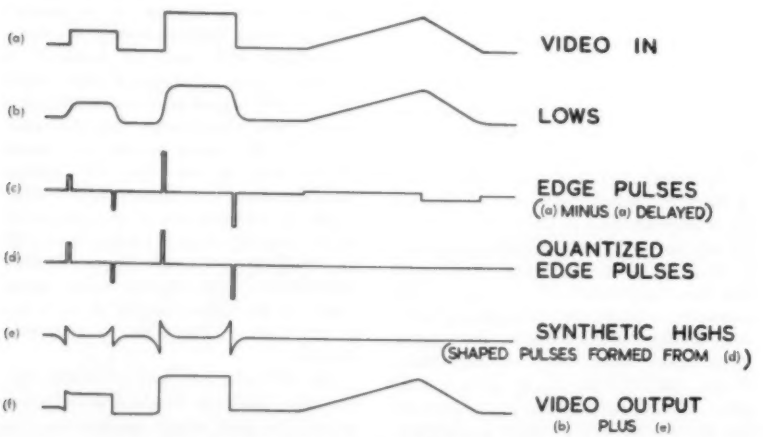


Fig. 2. Typical waveforms used in the Synthetic Highs System.

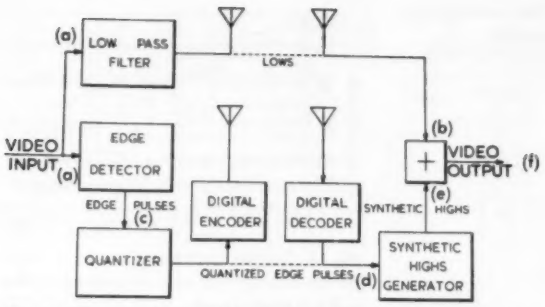


Fig. 3. The Synthetic Highs System. The signal notation refers to the waveforms of Fig. 2.

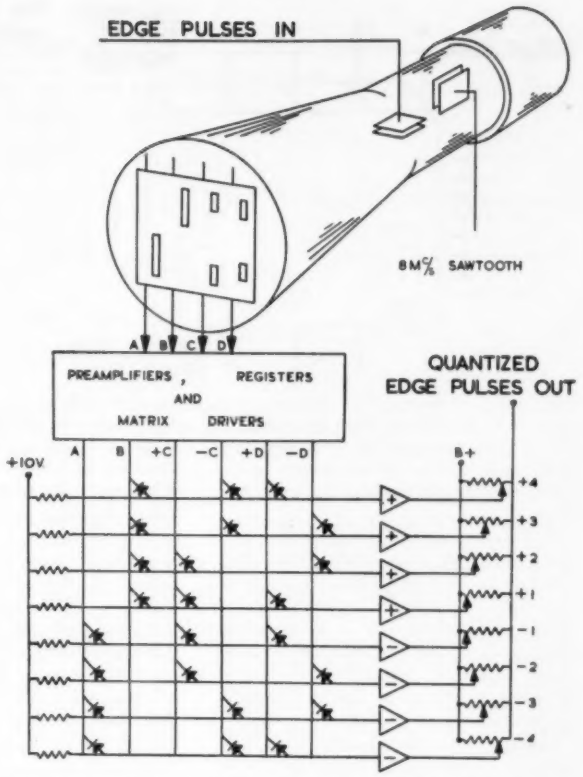


Fig. 4. The Quantizer showing coding-tube and diode matrix.

and trailing parts are mirror images of the corresponding portions of the lows signal. The shaping of the leading and trailing parts ensures that the synthesized highs blend with the lows without producing spurious edge contours. At the receiver, however, the highs are actually synthesized from waveform 2(d), which is transmitted by the digital coding system. These synthetic highs, when added to the lows of Fig. 2(b), produce the video signal 2(f). The quantization errors produce some over-and-under peaking, and the elimination of very low amplitude detail, but the net effect is quite satisfactory.

The purpose of the digital coding is to take advantage of the statistical nature of picture detail. In principle, the digital coder assigns two numbers to each edge pulse. One indicates its position on the line, while the other gives its quantized amplitude. The coder then transmits the pairs of numbers at a uniform rate. This rate is slower than that at which information is generated during complex picture detail, but faster than the information rate during relatively blank areas of the picture. The net result is the possibility of transmitting the coded edge information through a narrow-band channel. At the receiver, a digital decoder is required to reconstruct in real time the edge waveform Fig. 2(d) from the pairs of numbers received. The coder-decoder performs the function of elastic delay. The reconstructed edge waveform is passed through a highs synthesizer to produce a synthetic version of waveform Fig. 1(c) at the receiver.

The complete system is shown in Fig. 3. This diagram indicates two transmission channels, one for the lows signal and one for the quantized edge pulses. The quantized edge channel contains the digital coder and decoder, which take advantage of the statistical characteristics of the edge waveform. Also indicated are the units for the extraction and quantization of edges at the transmitter and the highs synthesizer and the lows-highs adder at the receiver.

Experimental Equipment

The main purpose of building this experimental equipment was to show the pictorial result of reconstructing a signal from low-frequency video by adding highs which have been synthesized from binary-digital edge amplitude and position information. The system was therefore connected as indicated by the dotted lines in Fig. 3. This means that the edge information is handled throughout in real time. Since the edges have already been quantized in time and amplitude, the coder-decoder merely transfers this binary-digital information, without change, from transmitter to receiver, thus exerting no influence on the quality of the final picture. The pictures do, therefore, contain all the effects, good or bad, that are inherent in the system as a result of quantization and binary-digital coding of edges and synthesis of the high-frequency content. We have also separately constructed and operated the digital equipment to prove its feasibility.

Another object of the experiments was to count the number of edges which occur in typical scenes from live television transmissions. From these data the bandwidth reduction of the complete system can be calculated. High-speed counters and display units from the digital coding racks available in the laboratory were used for this purpose.

Low-Pass Filter

This unit is designed to pass all frequencies below 350 kc with linear phase shift. Oscilloscope photographs of a square-wave input and the corresponding output are shown in Fig. 1(a) and (b).

Edge Taker

This unit must provide an output which is the difference between the video signal and the video signal delayed by $\frac{1}{8}$ μsec. A high-quality delay line is essential in order to avoid distortion, which would result in spurious edges. However, even the best delay lines distort, and it was found preferable to delay both video signals with similarly designed delay lines, one of which is $\frac{1}{8}$ μsec longer than the other. The difference between the two delay line outputs is the edge pulse waveform Fig. 2(c).

Quantizer

The bidirectional pulses from the edge-taker may have any amplitude between zero and the maximum voltage level of the video signal. The quantizer, Fig. 4, divides the available amplitude range into a relatively small number of discrete amplitude bands or quantum levels. All edge pulses whose amplitudes fall within an amplitude band are assigned the same value, which in some

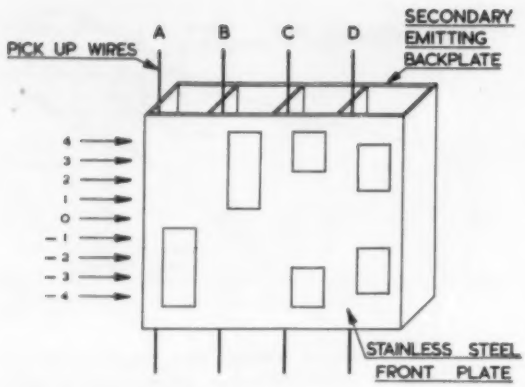


Fig. 5. The coding-tube target assembly.

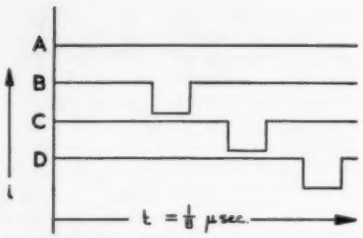


Fig. 6. Output currents from each digit of the coding tube corresponding to the +3 quantum level.

Table I. Distribution of Outputs of Coding Tube for Various Input Levels.

Quantum level	Code wire			
	A	B	C	D
+4	0	1	1	0
+3	0	1	1	1
+2	0	1	0	1
+1	0	1	0	0
0	0	0	0	0
−1	1	0	0	0
−2	1	0	0	1
−3	1	0	1	1
−4	1	0	1	0

cases will be larger than the original and in other cases smaller. The quantizer is adjusted to make the maximum quantizing error proportional to the quantum level.

A digital quantizer is employed rather than an analog type, primarily because the system encoder ultimately requires quantized amplitude information in digital form. Secondly, it is desirable when investigating the effects of quantization to subject the picture to exactly the same treatment as that accorded it by the transmission system.

Coding Tube. The coding tube is a specially constructed electrostatic focus and deflection cathode-ray target tube which generates a serial 4-bit code group, which identifies the quantum level corresponding to the input edge amplitude and polarity. The target is a boxlike structure as shown in Fig. 5. The frontplate, which is made of stainless steel, has four columns of coded holes. The beam is deflected parallel to the columns by bidirectional edge pulses, and at right angles to the column by an 8-mc sawtooth wave. When the beam is so deflected as to enter a hole, secondary electrons are emitted by the backplate. They are then collected by a wire electrode held several hundred volts positive with respect to the target. The wire runs parallel to the slot length, but is situated so as to prevent interception of the primary beam electrons, in order to obtain full advantage of the secondary emission from the backplate. There are four such wire electrodes, each serving as the output for one column or digit of the code group. When the beam does not enter a hole, no output is generated.

In operation, the electron beam constantly performs an 8-mc sawtooth scan across the target where no slots are encountered. An edge signal deflects the beam at right angles to the scan, in either direction, depending on polarity. A total of nine quantum levels, four positive, four negative, and zero are provided. Actually, since there are only eight active quantum levels, a 3-digit coding tube would have sufficed. A 4-digit tube is used in this equipment as a matter of convenience in the measurement of the number of edges per frame. The scan will transit one or more slots when the edge amplitude exceeds the zero quantum level. For either positive or negative edges, the particular combination of slots transited depends on which one of the four amplitude ranges contains the edge pulse amplitude.

The slots are arranged to conform to a reflected binary code such that for adjacent quantum levels the number of slots crossed changes by only one. This minimizes the deleterious effects of ambiguity arising from scanning along the boundary between adjacent quantum levels.

The 8-mc scan traverses the space between the outermost slots in about 0.08 μsec. Since edge pulses occur at random phase with respect to the 8-mc scan, it is possible that a scan which begins on one quantum level may finish on another, usually an adjacent one. However, the quantizing errors arising from this process are minimized by the use of a reflected binary code, as previously noted.

Table I shows the distribution of outputs on the four wires which are produced by the various input levels. Positive levels always produce an output on B and never on A. The reverse is true for negative levels.

The serial occurrence of the outputs is exemplified by Fig. 6, which refers to the +3 quantum level. The outputs on successive wires are about 0.02 μsec apart, and each output current pulse is less than 0.01 μsec in duration.

Preamplifiers. Each coding-tube output wire is coupled to a three-stage, high-gain wideband preamplifier employing EFP-60 secondary emission pentodes. The signal pulses are broadened by passage through the amplifiers. Wideband lumped-constant delay lines incorporated at the output of the preamplifiers driven by wires A, B and C convert the serial coding-tube outputs to the simultaneous presentation ultimately required by the decoder matrix. The delay-line outputs are each further amplified by a 6351 secondary emission pentode prior to application at the register triggering circuits.

Registers. It is desirable to drive the diode matrix decoder with pulses standardized in amplitude and shape. Each of the four signal channels drives a register composed of a high-speed flip-flop and associated triggering circuits. The flip-flop uses E180F pentodes and is capable of about 29-mc operation. Clock pulses are applied to the other side. To assure positive operation, the clock pulse triggers are deleted, when signal triggers are present, by means of a cancellation circuit. The register outputs provide $\frac{1}{8}$-μsec pulses of uniform amplitude and shape which are direct-coupled to the matrix drivers.

Matrix Decoder. The matrix decoder is a network of signal-operated diode gates which converts the four-channel digital code group derived from the coding tube into a single-channel analog output — the desired amplitude quantized edge pulses.

The diode matrix has inputs corresponding to the columns in the coding-tube target and eight output leads, each of which corresponds to one of eight quantum levels. Each matrix output lead is direct-coupled to an output tube which in the quiescent condition is biased to cutoff as a result of conduction by some of the matrix drivers. When a code group arrives at the matrix driver inputs, the conductivity state is reversed in some or all of them, thereby altering the matrix diode conduction paths.

The matrix recognizes the quantum level conveyed by the code group and sorts out an enabling voltage to one

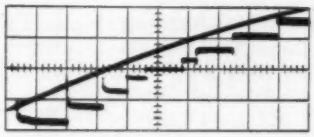


Fig. 7. Part of a 15 kc/sec sawtooth waveform before and after quantization. This oscillogram illustrates the tapering of the quantizer levels.

and only one of the eight output tubes, turning it on. Four of the output tubes are regular pentodes, and consequently produce negative outputs when turned on. The other four are secondary emission tubes from whose dynodes positive outputs are obtained when the tubes are turned on. The output amplitude of each tube is separately controlled by the adjustment of an individual potentiometer. Since only one tube is responsible for the output at any given time, summation of quantum levels does not occur, and therefore the setting of any output quantum level is independent of all other output quantum levels. This feature facilitates adjustment of the quantizer output characteristic. All output potentiometers have a terminal in common from which the quantized bidirectional edge pulse output is taken. The output is connected to the synthetic highs generator. An example of the input and output of the quantizer is given in Fig. 7.

Synthetic Highs Generator

There are various ways by which the shaped highs pulses of Fig. 2(e) could be generated from the $\frac{1}{8}$-μsec-wide edge pulses, Fig. 2(d), delivered by the quantizer.

One method we have used is to feed the edge pulses into a long delay line having 12 taps, each separated by a $\frac{1}{8}$-μsec interval, as shown in Fig. 8. The outputs from all taps are then suitably weighted before being added to form the desired highs output. This is a standard time-domain synthesizer.

The highs waveform as synthesized by this method contains a small 8-mc ripple due to the addition of pulses separated by $\frac{1}{8}$ μsec. This would be almost invisible under normal viewing conditions, but in any case it is removed by a 4-mc filter.

Digital Equipment

We have given a complete report on the digital coder and decoder in an earlier paper.[1] Although these units were by-passed in this experiment, they are required in an operating system, and since an understanding of their principles is necessary for what follows, a shortened description seems in order at this point.

As has been mentioned, these devices constitute an elastic delay. That is, they store information relative to the fine detail of the picture at whatever

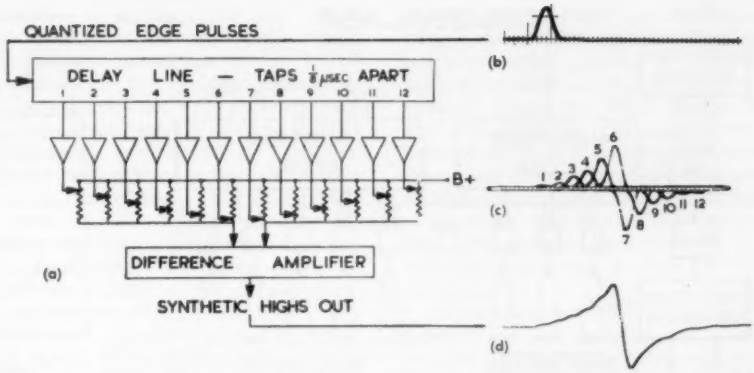

QUANTIZED EDGE PULSES
(b)
DELAY LINE — TAPS $\frac{1}{8}$ μsec APART
1 2 3 4 5 6 7 8 9 10 11 12
B+
(c)
1 2 3 4 5 6 7 8 9 10 11 12
(a)
DIFFERENCE AMPLIFIER
SYNTHETIC HIGHS OUT
(d)

Fig. 8. (a) Block diagram of the Synthetic Highs Generator; (b) a quantized edge pulse input; (c) a multiple exposure showing weighted outputs from the 12 delay-line taps; (d) The synthetic highs output waveform resulting from input edge pulse (b).

rate it is generated by the scanning action of the original picture source. This rate will be high when the scanned area contains much detail and low during scansion of relatively blank areas. When a certain quantity of information has been stored, it is then read out of storage for transmission through the channel at a uniform rate. In this way, the average information content determines the channel bandwidth, rather than the peak content as in uncoded systems. At the receiver, the decoder must again store the information, reading it out in real time. The storage period must be long enough to obtain a good statistical sample of the signal. One field is used in this system, although in applications where the detail content would be expected to be distributed more uniformly than in entertainment-type television pictures, a shorter period might be used.

The physical structure of the coder and decoder is determined by the storage device. At the time this work was undertaken, only electrostatic storage tubes were capable of operating at the high rate (8 mc) required, but now there are other more compact devices which show promise. Of the various tubes available, the Radechon single-gun barrier grid tube was selected. It is an electrostatic deflection type in which information is stored in the form of spots of charge on a mica target. Writing is carried out by turning on the beam for a short time while it is directed at the desired point on the target. Reading is accomplished by discharging the target with the beam, the output signal being the discharge current which flows in the backplate, which is connected to a potential source through a load resistor.

The information that must be stored is the amplitude and position of each edge in the field. As has been explained, visual effects permit the edge amplitude to be described by only three bits. The positional accuracy of the edges, however, must be high, because it is this which determines the resolution of the system and the registration of successive scanning lines. To preserve the properties of a 4-mc video bandwidth in these respects requires that there be 8 million discrete edge positions per second or about 425 per active scanning line (one per picture element). We provide for this purpose a clock pulse generator. It produces a train of 8-mc pulses synchronized with horizontal pulses. Each edge is then designated by the nearest clock pulse. There remains the question of the most efficient code for securing this designation.

If we call the interval between successive edges, measured in clock pulses, a run, then it is evident that a run may be from 1 to 425 clock pulses long. For each run length, there will be a certain probability of its occurrence. If we measure the probability distribution of run lengths, we can then construct a Shannon-Fano[14] code. Such a code results in the highest efficiency (i.e., the least bits per second on the average), but it does so at the expense of substantial complexity, because in general each different run length will use a different length code, lengths of high probability having short codes and vice versa. The instrumentation of such a system seems possible for facsimile[15] but not for television in the present state of the art. We are therefore limited to constant-length codes, which are of maximum efficiency only in the case of equally probable run lengths. Since short runs are in fact more common than long runs, and very long runs (over 30 or so picture elements) are rare, we shall have sacrificed efficiency for simplicity. A large part of the efficiency can be recouped at relatively small additional complexity by using a 5-bit code group for run length. Such a code group can correctly represent runs up to 32 picture elements in length, longer runs being handled by being broken up into a number of subruns not larger than 32 elements. It turns out[1]

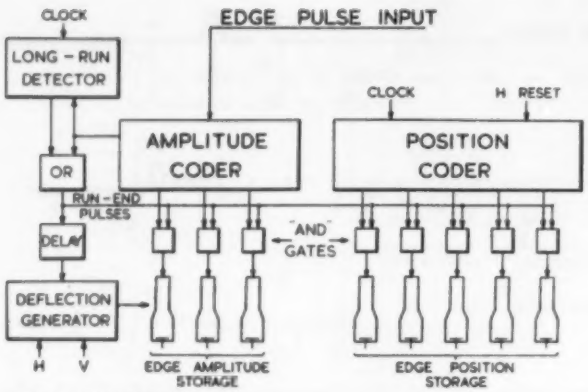


Fig. 9. The Digital Encoder.

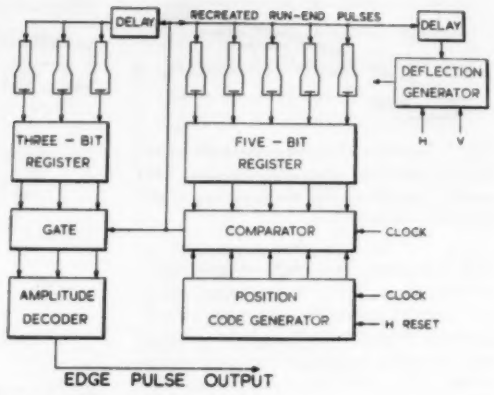


Fig. 10. The Digital Decoder.

that the best choice of size of code group depends on the average run length, a 5-bit code being optimum for an average run length of about 20 picture elements.

A particularly convenient constant-length code for run length is the reflected binary code representation, since it is simple to generate and avoids certain types of sampling errors. The final design point to be mentioned is that a constant-length code for run-end position is precisely as efficient as a constant-length code for run length. Since the former is somewhat simpler to instrument than the latter, it is preferred.

Turning now to Fig. 9, we shall describe the operation of the encoder. Eight storage tubes are provided, five to record the 5-bit position code and three to record the 3-bit edge amplitude code. All tubes are deflected from spot to spot at the same time by the deflection generator, so that all the bits for each edge are stored in corresponding spots in the tubes. The position coder is a scale-of-32 reflected binary counter, the five stages of which provide the signal input, via "and" gates, for five of the storage tubes. The amplitude coder is, for example, a coding tube of the type previously described. The three digits representing the edge amplitude constitute the inputs for the remaining three storage tubes, via three more gates. Whenever a significant edge occurs, a "run-end pulse" is produced which opens all eight gates to store the necessary information. After a short delay (about 0.06 μsec) the deflection generator moves all the beams to the next storage position to wait for the next edge. The long-run detector is a conventional scale-of-32 counter which is advanced by clock pulses and reset by run-end pulses. Whenever a run is 32 or more elements in length, the counter will recycle, producing an extra pulse called a "long-run pulse" which is added to the run-end pulse train, thus storing extra code groups every 32 elements in long runs. At the end of the field, the amplitude and location of each edge in the picture will have been stored. In the ensuing field, the information is read out and transmitted through the channel at a uniform rate.

At the receiver, the pulses are stored in exactly the same pattern as at the transmitter. The storage tubes are then switched to the reading mode, and the process shown in Fig. 10 is ready to begin. This process restores the time scale of the edge information. Let us suppose that the first edge was of amplitude 3, located in position 15. At the beginning of the first line in the decoding cycle, the numbers 3 and 15 are read out of storage and held in registers. The position code generator commences counting clock pulses, constantly comparing the count with the position code held in the 5-bit register. When 15 pulses have been counted, we have now arrived at the same time in the line where the edge was originally located. A coincidence occurs which releases the edge amplitude digits from the 3-bit register for decoding and use in the synthetic highs generator. An instant later, the information concerning the second edge is read out and held in the registers waiting for the correct time to be used. The process is repeated until the entire field is decoded.

Because the storage tubes used read and write alternately and not simultaneously, two sets of tubes must be provided at both transmitter and receiver, so that one set may be reading while the second set is writing.

Nothing has been said so far about the lows signal, which is transmitted in real time. Since the digital coding and decoding process effectively delays the highs by two fields (or frames — whatever the averaging period is), the lows must also be delayed. Because of the low definition, this presents no problem. A single Radechon storage tube operating as a scan converter has adequate resolution, although it is not entirely out of the question to consider the use of a magnetic drum.

Pictorial Results

We have endeavored to select a series of picture-tube photographs illustrative both of the basic principles of the system and the quality of the reconstructed picture. Achieving the latter aim is difficult, since every still photograph of a TV picture is to some extent an inaccurate reproduction. Noise and other frame-to-frame dissimilarities are integrated by the eye in one way and by the still camera another way. For this reason, in the oral presentation, a motion-picture TV recording was used.

Figures 11(a) through (f) show the video signal in various stages of processing in the system. The letters correspond to the idealized waveforms of Fig. 2. The original was a low-noise signal from a flying-spot scanner, as was the original of Fig. 11(g). In analyzing these two subjects, it should be borne in mind that the purpose of the television system is to transmit pictures, not test patterns. These artificial subjects — useful as they may be for process control in answering such questions as "Was the printer in focus?"— have only limited meaning in comparing widely differing processes. It is for this reason that the unwary, seeing the moire in the vertical fan in Fig. 11(f), may be surprised at the excellent reproduction of Fig. 11(h). Part of the moire is produced by beating between the picture material and the 8-mc sampling frequency, and part by an alternation between two successive quantum steps as an almost-vertical contour is sampled at slightly different points on successive scanning lines.

The quality shown in Fig. 11(h) is typical for low-noise original pictures. The only visual effect observable on the kinescope, but not adequately shown on the photograph, is some apparent increase in noise in the highly detailed areas. The overall quality is entirely acceptable.

In Fig. 12 we have shown a series of off-the-air pictures, split in the center so that one side contains the original and

the other the reconstructed signal. We have purposely alternated the relative portions and refrained from identifying the sides in order to illustrate the fact that the reconstructed pictures are of commercial quality.

Degree of Bandwidth Reduction

The degree of band saving obtained and the field of application of the system are determined by considering what signals need to be transmitted, and comparing these with a conventional system. The comparison is easiest if the "conventional" system is 128-level Pulse Code Modulation with 7 bits/signal sample. For an ideal* 4-mc bandwidth, a sampling rate of 8×10^6 pulses/sec is used, for a total bit rate of 56×10^6 bits/sec. In the synthetic highs system, the "lows" of 350-kc bandwidth would require a sampling rate of 0.7×10^6 pulses/sec or 4.0×10^6 bits/sec for 128-level accuracy. Our measurements show that an overwhelming majority of pictures contain less than 900,000 edges/sec. Each edge takes three amplitude digits and five position digits, for a total of 7.2×10^6 bits/sec. The two signals combined require about 12×10^6 bits/sec, or somewhat less than one-fourth that of the conventional system. This comparison may seem to be academic because digital television systems are not now used, but digital communication systems are becoming increasingly important as new means of long-distance transmission are developed. In such a digital system the 4 : 1 reduction in bit rate may be utilized by decreasing either the transmitter power or channel bandwidth or both, as the economic situation may dictate. An attractive alternative for some systems, especially in remote areas, is to keep the transmitter power unchanged and to take advantage of the increased signal-to-noise ratio (due to narrower bandwidth), to increase the distance between relay stations.

For channels or recording devices not inherently digital, it is harder to make a precise comparison between synthetic highs and conventional transmission. In these cases, it is probably better not to digitalize the edge amplitudes. Instead, at each picture element the edge amplitude is measured. If it exceeds the level of the zero quantum step, its analog value is recorded as a discrete spot of charge in a continuous-tone storage tube, while its position is digitally recorded in the "position" storage tubes as usual. In readout, the signal from the amplitude storage tube is a succession of pulses of varying heights. For 900,000 runs/sec, a bandwidth of 450-kc is necessary for this signal, in addition to 350 kc for the "lows" signal plus 5 bits/run or 4.5×10^6 bits/sec for the position information. There are various ways in which these three signals can be combined in a nondigital channel. If the signal-to-noise ratio is such as to allow reliable recognition of eight discrete amplitude levels, then 1.5×10^6 pulses/sec would carry the digital information. This uses 0.75-mc bandwidth, giving a total for the three signals of 1.55 mc plus guard bands, or something under 2-mc. While this may not seem a very large reduction, it would, for example, permit a 2 : 1 reduction in head-to-tape speed in a video-tape recorder, or double the range of a troposphere scatter system.

A special case of a nondigital channel is the submarine coaxial cable. Unlike other relay systems, which modulate a carrier with the information to be transmitted, submarine cable systems use as low a frequency band as possible, i.e., the video itself. This is because cable attenuation increases rapidly with frequency. The spacing of repeaters is governed by the distance at which the amplitude of the various frequencies in the band have been attenuated to a level at which the noise contributed by the amplifier becomes significant by comparison. Reducing the bandwidth not only reduces the amplifier noise, thus increasing the allowed spacing between repeaters, but also further reduces the high-frequency attenuation, allowing an additional increase in spacing. When designing for a given degree of reliability over a long route, the large reduction in number of repeaters would substantially reduce the cost of the cable system.

Scan Conversion in the Synthetic Highs System

The digital data transmitted contain the location and amplitude of the fine detail in the original picture. The time of transmission of information relating to a specific picture element is unrelated to the real time at which that element occurred in the original video signal. The original real-time scale is recreated at the decoder by generating successive position codes at the same rate as at the encoder. This is ordinarily accomplished by using the same clock pulse frequency in both equipments. It is not necessary to synchronize the two frequencies exactly, but it is necessary to use the same number of clock pulses per video line to keep the decoded information where it belongs.

This asynchronous property of the system makes it possible to encode and decode signals on different scanning standards, a useful ability in international transmission. Let us first consider interchange between two systems having the same field rate but different numbers of scanning lines. There are two basic steps in the conversion process. First we stretch or shrink each line of video in time, to accommodate the systems horizontally. Second, we either discard or use twice entire lines of video to accommodate the systems vertically. Naturally, one cannot expect the resultant picture to have more definition than that of the poorer system. Hence, to economize on transmission bandwidth, any information discarding is done at the transmitter.

Any one video line which originally occupied x μsec can be decoded in y μsec by using a decoding clock frequency x/y times the encoding clock frequency. For example, in converting from the French 819- to the British 405-line system, the 3-mc bandwidth of the lower definition system calls for a 6-mc clock rate. The active portion of the horizontal scan period is 81.6 μsec, giving $81.6 \times 6 = 490$ clock pulses/line. The active portion in the 819-line system is 40.8 μsec. To have 490 pulses/line requires a clock frequency of $490/40.8 = 12.0$ mc. In going from 819 to 405 lines, every other line would be discarded before coding. In the reverse direction, each decoded line would be used twice by means of a delay line or similar device.

If the line numbers are not near 2:1, then other expedients are used. Following is a table of possible methods.

Conversion		*Method*
From	*To*	
405	441	Leave 18 lines blank top and bottom
441	405	Omit 18 lines top and bottom
405	625	Use every second line twice
625	405	Omit every third line
405	819	Use each line twice
819	405	Omit every second line

The frame-rate conversion process can be similar to that used in kinescope recording 30-frame pictures onto 24-frame film. Basically, just as in line-number conversion, in going from a higher to a lower rate system, information is discarded, while in the reverse direction some information is used twice. No extra equipment is required. Since there always must be two sets of storage tubes at both encoder and decoder, the operation is conducted merely by controlling the read-write cycle of each tube. The scan conversion chart (Fig. 13) shows how 30-frame material may be coded so that decoding at 25 frames/sec is possible.

Future Developments

We previously pointed out[1] that any operation on the video signal which reduces the number of runs without losing information, such as line-to-line or frame-to-frame differencing, would substantially improve the efficiency. It appears

* For accurate reproduction of a sine wave, slightly more than 2 samples/cycle are necessary. However, since video signals do not contain large amplitude 4-mc sine waves, we may omit this slight correction, which of course applies equally to ordinary PCM.

Fig. 11. Parts (a)—(h): Kinescope photographs

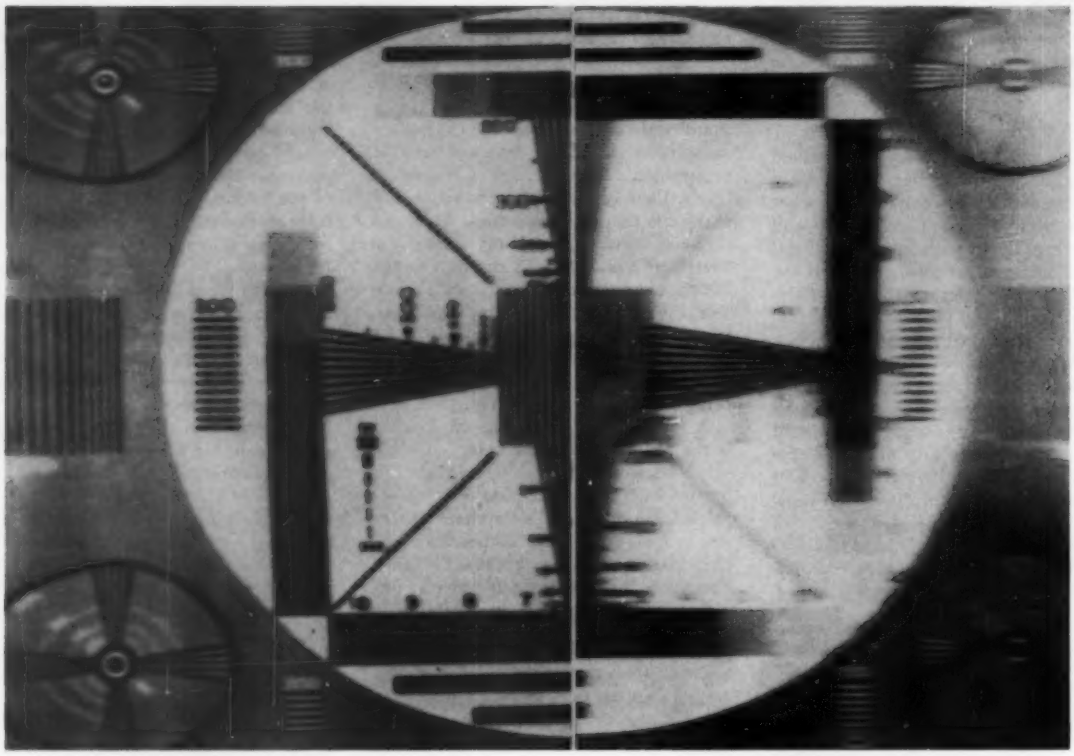


Fig. 11 (a). Original video test pattern.

Fig. 11 (b). Lows content.

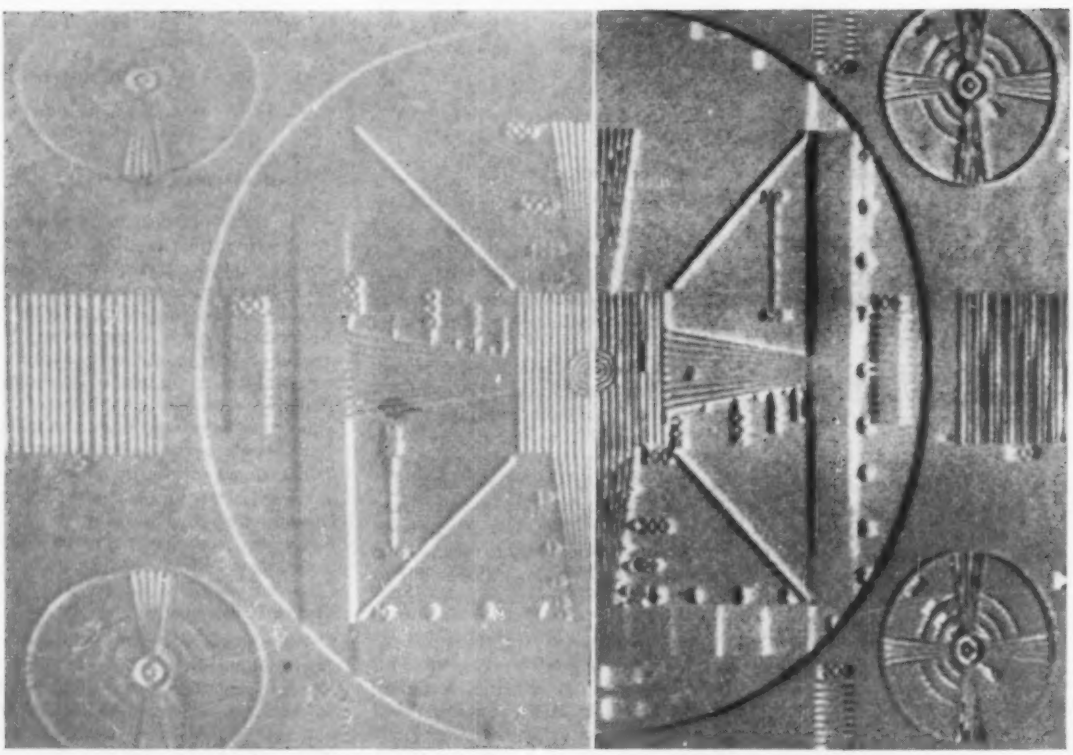


Fig. 11 (c). Edges or difference signal.

Fig. 11 (d). Quantized edges.

of test charts from a flying-spot scanner.

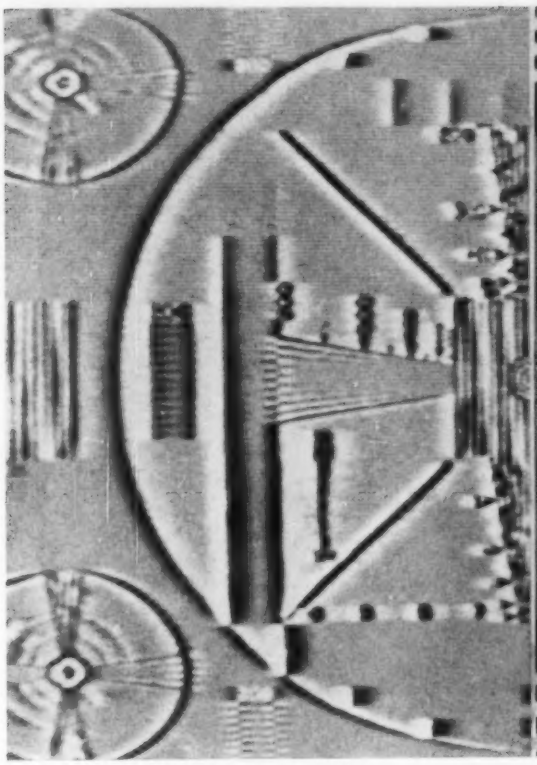


Fig. 11 (e). Synthetic highs.

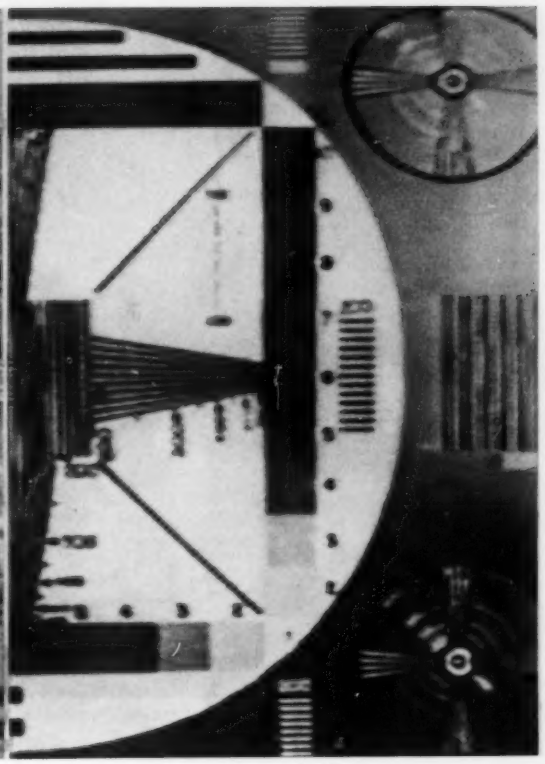


Fig. 11 (f). Reconstructed video test pattern.

Fig. 11 (g). Original video.

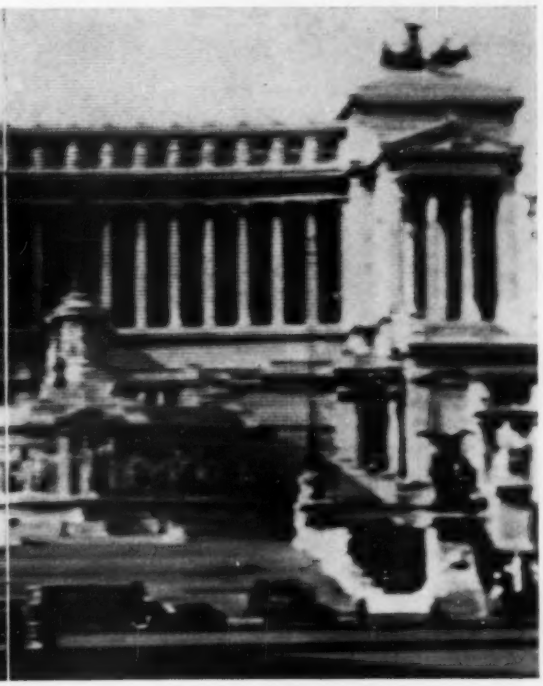
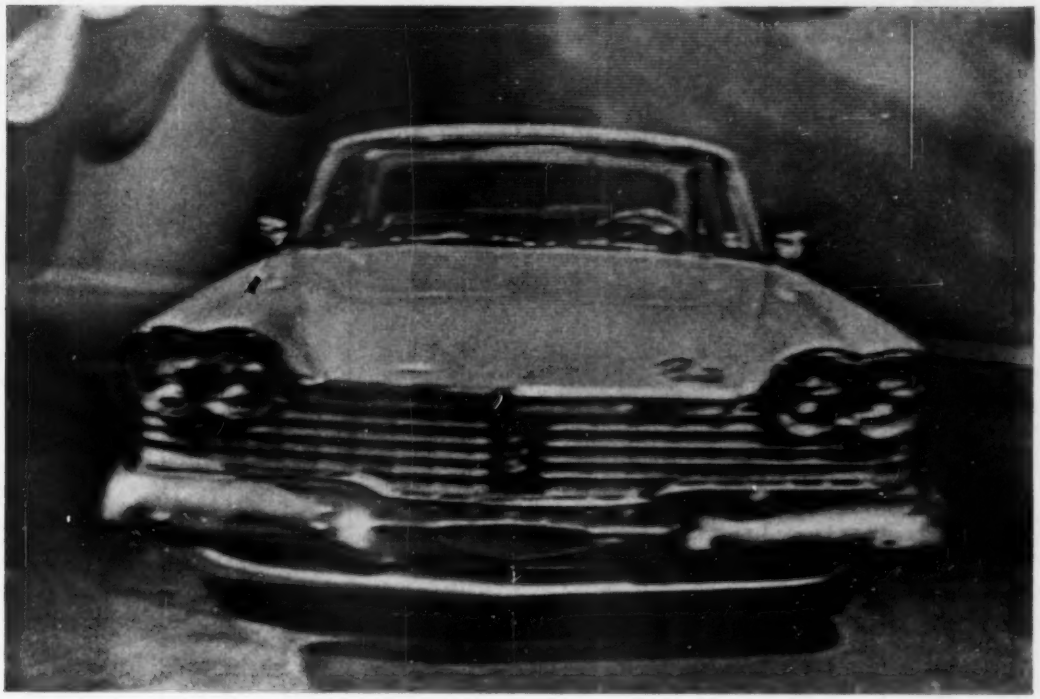
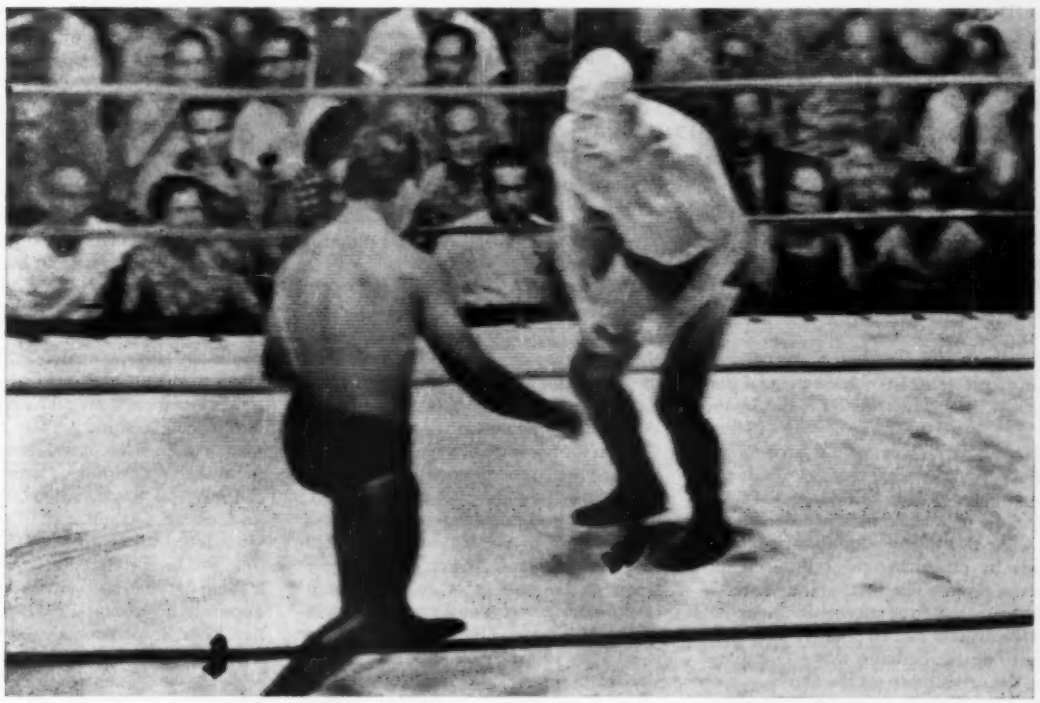


Fig. 11 (h). Reconstructed video.

Fig. 12. Kinescope photographs of off-the-air pictures.

The center line divides the pictures into original and reconstructed halves.





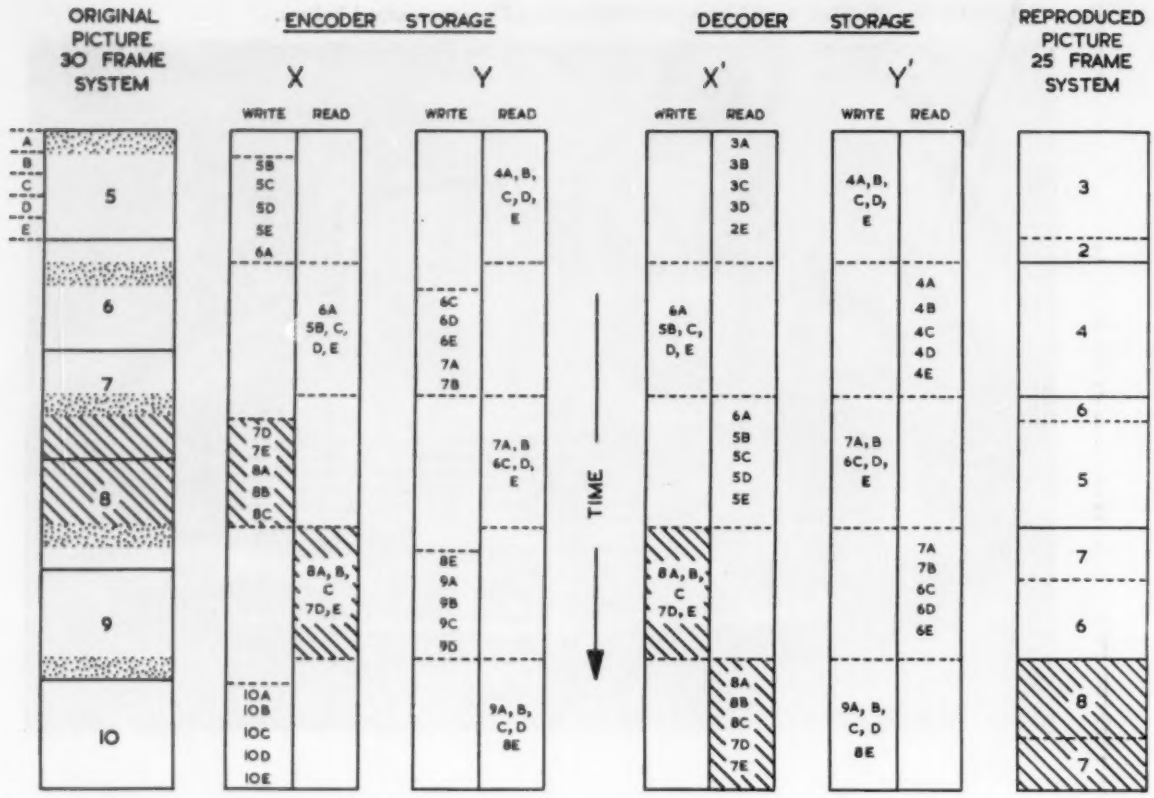


Fig. 13. Scan conversion chart; conversion from 30 to 25 frames/sec.

The lefthand column shows six successive fields in the original 30-frame system, and the righthand column shows five successive fields in the final 25-frame system. The numbers in the reproduced fields show which field of the original the video information came from. Each field is divided into five sections, labeled A, B, C, D, E for identification. There are two sets of storage tubes at the transmitter and two at the receiver. Set X is transmitted and written into X'. Likewise Y reads out for transmission to Y'. All storage tubes write in real time at the transmitter and read in real time at the receiver, but the operation of reading out for transmission and re-storing at the receiver is done at a uniform information rate to save bandwidth, and is also done out of order so that the correct geometrical arrangement is preserved. The dotted portions of the original frames are discarded.

The cross-hatched areas show the path through the system of one field of information: 60% through field 7, storage tube X commences writing and continues for exactly 1/60 sec. At the end of that time it has stored one full field, although 40% is from field 7 and 60% from field 8. In the ensuing 1/50 sec this information is read out at a uniform rate and restored in storage X' at the receiver. Note that the order of read-out is different from the order of write-in, so that the material stored in X' will be in the correct geometrical order. In the next 1/50 sec the information is read out by the decoding circuitry in real time and appears as the final field in the righthand column.

that there is another promising attack. Our experiments have demonstrated that when a significant edge is found in the picture, a very satisfactory rendition is achieved by measuring the edge amplitude and synthesizing the high-frequency components of the video signal. In the technique described above, a decision as to what constitutes a significant edge is made by measuring the cell-to-cell difference signal. The first quantum step is set low enough so as not to miss important low-contrast detail. In practice a compromise is struck between this requirement and the necessity to set the first quantum step high enough to avoid erroneously deciding that noise peaks are edges. While such erroneous decisions do not make the picture look much noisier than the original, they do reduce the system efficiency by requiring additional transmission of information. It appears from some preliminary work we have done that a more sophisticated test can be made of the presence of a significant edge, so that fewer noise peaks will be counted as edges.

Another possibility for improvement is in reduction of the bandwidth allotted to the lows signal. At first glance, there seems to be no special reason why it could not be very much smaller than 350 kc. The shape of the highs component is entirely arbitrary, and a slower rise time of the lows could be matched by a longer highs pulse at each edge. Unfortunately, this is not quite true. What we transmit, essentially, is a quantized cell-to-cell difference signal. If no lows at all were used, it would be possible to reconstruct an approximation of the entire video merely by integrating the edge pulses along each line. The operations of differencing and integration are complementary. Such reconstruction would err because the edge pulses themselves, being coarsely quantized, when added up in an integrator would lead to errors in the video level. While not serious on any one line, the level difference would be quite evident between successive lines. It would appear as horizontal streaking, something like poor low-frequency response. Regarded on that basis, the reason for using a lows component is quite straightforward — it obviates the necessity of transmitting edges which are accurate enough to permit exact formation of the lows component by edge integration.

Now if the lows bandwidth is not zero,

but is, say, one-fourth of the present value, the picture quality would be impaired by the presence of alternate white and dark tails extending horizontally around each corner or vertical contour in the scene. It appears that with the present system of edge selection and coarseness of quantization, no further reduction is possible. It may well be that a slight improvement in edge accuracy by using 16 quantum steps, for example, would be more than offset by a narrower acceptable lows component.

We now believe that it is possible to some extent to distinguish between real detail and noise on the basis of the conditional probability distribution of several successive picture elements. Analysis indicates that about a 50% further reduction in edge information transmission may be achieved.

Conclusion

The purpose of the work discussed above was to demonstrate that high-quality video signals may be produced by adding to the low-frequency component of an original signal, a synthetic high-frequency component generated from relatively few, coarsely quantized cell-to-cell difference signals. With the aid of a digital coding system, the information from which the highs are synthesized can be transmitted in a relatively narrow bandwidth.

It is to be emphasized that, although the improvements so far reported are large enough to be of genuine commercial importance, additional developments, such as line-to-line or frame-to-frame differencing before coding, and a more sophisticated edge selection, are expected to yield even greater reductions.

Acknowledgments

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The oral presentation included a TV film recording showing the operation of the system on off-the-air signals. The equipment was made available through the courtesy of Ralph E. Lovell of NBC. The subjects were *Romper Room*, *Milady*, and *Skipper Frank*, used with the generous permission of KTLA.

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Discussion

T. Worswick (*B.B.C., London*): We appreciate very much the author's skill in presenting a very difficult subject extremely well. The important point in television pictures, that is if you want to get good-looking pictures, is that frequencies below a $\frac{1}{2}$ mc must be right and above a $\frac{1}{2}$ mc you can take substantial liberties with the signal. The question therefore is what future work will be done in the 0- to $\frac{1}{2}$-mc region and how much damage will be done to the picture if the lows bandwidth is reduced?

Dr. Schreiber: There appears to be a relationship between the accuracy of the edge amplitude rendition and the low-frequency bandwidth that's required. If the edges were transmitted with absolute amplitude accuracy, the entire video signal could be reconstructed merely by integrating the edges, since the operations of differentiation and integration are complementary. The lows signal is an error corrector which corrects for the fact that edge amplitudes, which are difference signals, have been quantized, and are therefore inaccurate. If you take a difference signal and integrate it, you get back the original signal. But if you take a difference signal which has errors in it and integrate it, you get back your original signal with level drifts. These drifts will be noticeable from line to line so that the more accurately you render the amplitude of the edges the narrower the low-frequency component can be. We actually have tried it with 175 kc, but it appeared to be not quite good enough with the three-bit edge amplitude information. The next step will be to go to a four-bit edge amplitude which increases the required bandwidth for the highs only slightly.

Mr. Worswick: What happens when you quantize the signal down the field?

Dr. Schreiber: I anticipate that when we do this the lowest component will really be a low-definition picture, that is it will have fewer numbers of lines in it and we will put in the edges both vertically and horizontally by technique very similar to the way we do now. As a matter of fact, if you take the synthetic highs generator, and instead of having a delay of $\frac{1}{2}$ μsec you have $63\frac{1}{2}$ μsec, you have a vertical edge synthesizer, so to speak. It's a lot harder to build, but that generally is what we have in mind.

J. R. Popkin-Clurman (*Telechrome Mfg. Corp.*): The clock pulses were nonsynchronous or synchronous applied to the pictures that you used?

Dr. Schreiber: Clock pulses are synchronized with the horizontal frequency — that is, we have an oscillator which is started by every horizontal pulse and stopped at the end of the line. It is not necessary that the receiver clock frequency be synchronous with the encoder clock frequency. All that is necessary is that the same number of clock pulses per line be used so that you get your information back in the correct line of the picture. As a matter of fact, the frequencies can be so asynchronous that they can be entirely different. It is possible to take the information out of storage on an entirely different time scale.

Mr. Popkin-Clurman: Do you find that you might make use of additional bandwidth reduction by frequency interleaving if you did use it on a line basis?

Dr. Schreiber: I presume that all the usual tricks for saving bandwidth by interlace would be applicable to this signal. This system takes in a real time video signal and it produces a real time video signal — there's no stop-start scanning in picture space or any business like that which has never, in practice, worked out.

Dr. William L. Hughes (*Iowa State College*): At the beginning of the paper, you noted that you need two things for resolution: position and amplitude. Have you explored the possibility that position may not be nearly as important if you have the amplitude? In other words, was your 8-mc sampling rate determined by some optimizing of this situation?

Dr. Schreiber: The sampling rate is determined by the fact that we're trying to handle a 4-mc picture. And it is generally agreed that you need two samples per cycle.

Dr. Hughes: Would there be a subjective degradation — a severe one, in the picture? Every time you had a sharp edge in the original you got a sharp edge, but it might be one or two picture elements displaced?

Dr. Schreiber: That would be pretty serious if the displacement was line to line. As a matter of fact, one of the great things to be said about the regular television system is that the line-to-line registration is so good. I think you can see displacements of one part in a thousand very easily in successive lines.

Ed Dyke (*Page Engineers*): Do you have a target value in mind for the ultimate bandwidth for monochrome and also for color and have you experimented with color?

Dr. Schreiber: No, our company has not experimented with color for this particular application. Of course, we have done some color work in other fields. There is no special target — when I first got interested in this work I asked Norbert Weiner what he thought and he rattled off — "100 to 1" — which is a pretty big reduction. I would be happy with 4 to 1.

A New Approach to Balanced Audio Levels in Television

By ROBERT B. MONROE

A study of television audio levels was recently undertaken by the CBS Television Network as a result of complaints from television viewers that some portions of television programs sound too loud. The findings of this study are presented and a new method of achieving balanced audio levels in broadcasting is described.

For some time, television viewers have registered complaints that portions of television programs are sometimes unpleasantly loud. Accordingly, in an effort to present programs in the most pleasing manner possible, the CBS Television Network recently completed a new study of audio volume levels. This study was for the express purpose of fully exploring the reason for these complaints. This paper presents the findings of the study and describes a new approach to the problem of achieving balanced audio levels in television broadcasting.

Study of TV Sound Levels

The new CBS study of television audio levels, which was an extension of similar studies undertaken some years ago,[1,2,3] got underway late in 1957 with the establishment of an observation point in the CBS Television Network Engineering Laboratory where television programs could be monitored in an environment acoustically similar to the average home living room. To further simulate home listening conditions, the monitoring volume was maintained at a level similar to that normally used in the average home.

The laboratory observation point was fully equipped with measuring equipment to analyze and measure audio program material. Programs could be monitored by wire line directly from the originating studio or off-the-air, the latter signal having passed through the transmitter and its associated automatic-gain-adjusting amplifier.

Observation of programs continued over a period of several months. During this time, a permanent record of audio levels was made by means of a recording volume indicator, the continued use of which has proven very valuable in regular operation. Where levels were considered questionable magnetic-tape recordings were made to permit more detailed analysis.

Observations and Findings

It has been the usual practice in both radio and television broadcasting to transmit audio program material at a uniform peak volume level as read on a standard volume indicator.[4,5,6] At first consideration, it might be thought that this practice would automatically result in all portions of the program material sounding equally loud. However, this is not always the case as the standard volume indicator measures audio volume,[7] not loudness. Inasmuch as loudness is subjective in nature, it does not readily lend itself to measurement.

Quite early in this study of television audio levels, it became evident that, as listeners had reported, some television program material did sound louder than other material. The "loud" material included filmed program inserts in live programs, some program opening and closing announcements, and some station-break announcements.

Reasons for Loudness Discrepancies

As the study continued, it was found that there are three distinct reasons for differences in the loudness of various portions of programs:

1. Modification of Audio Waveform. One of the factors influencing the apparent loudness of audio program material was found to be the use of techniques that alter the waveform (and hence the subjective effect) of an audio signal. The following practices all result in the altered audio signal sounding louder than the original even though both are transmitted at the same peak value as measured by a standard volume indicator:

Volume Compression. Program material that has been compressed, thereby restricting its original amplitude range, will sound louder than similar uncompressed program material.

Reverberation. Reverberant program material will sound louder than program material that is acoustically dead. This principle was the basis of J. P. Maxfield's "Liveness in Broadcasting" technique[8] introduced in 1947 and still in common use in radio broadcasting and phonograph record manufacture. Maxfield reported the possibility of a 6- to 8-db apparent increase in loudness using acoustically live program pickup techniques.

Bandwidth Restriction. When wave filters are employed to attenuate low frequencies, a considerable portion of the energy is removed from an audio signal, and its level, as read on a standard volume indicator, must often be raised if standard transmission level is to be maintained. Furthermore, most of the the remaining sound energy occurs in the middle frequency range where the ear is most sensitive. Program material so restricted in bandwidth will, therefore, usually sound louder than full-bandwidth program material (although it suffers in faithfulness of reproduction). By the same token sounds having predominantly mid-frequency components will exhibit a similar apparent greater loudness.

The above techniques are often employed (individually or severally) in producing the soundtrack of sound-on-film television program inserts. To a considerable extent, these practices account for such filmed inserts sounding louder than the unmodified live-studio sound pickup.

2. Listener Reaction. Another factor that influences the apparent loudness of television program material is associated with listeners' subjective reactions to certain types of sound, such as:

Irritating Sounds. An irritating voice, like any irritating sound, often seems louder than a pleasant one even though both may be reproduced at the same volume level.

Strident Delivery. Speech delivered in a rapid-fire, strident manner with few pauses, if any, sounds louder than speech delivered in a more conversational manner.

In this study of audio levels it was noted that program material delivered in a rapid, urgent manner by an announcer or performer with a slightly irritating quality in his voice invariably sounded louder than more normal adjoining portions of a program.

3. Program Peaking Practices. The third and perhaps the most important single factor that was found to influence the loudness of television program material is the program peaking practice employed in controlling audio levels at the audio console of the originating studio. Over ten years ago, after extensive investigation, program transmission standards were established by CBS[9] in order to produce programs with audio levels as pleasing as possible to the listener. Occasional cases of loudness discrepancies resulting from incorrect program peaking practices were observed during this study, indicating that the program

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(This paper was received on May 26, 1959.)

transmission standards were not being observed. However, unlike loudness discrepancies resulting from the reasons discussed in the preceding paragraphs, loudness discrepancies resulting from incorrect program peaking practices are readily visible as nonstandard deflections of the volume indicator.

A Solution

As indicated above, a most important requirement in achieving pleasing sound levels is good control of audio program peaks at the audio control console of the originating studio. Nevertheless, good audio control in itself will not reduce excessive loudness when it is caused by (a) the use of techniques that modify the audio waveform, or (b) the reaction of listeners to certain sounds. Other means must be used to make these types of program material match other portions of the program in loudness.

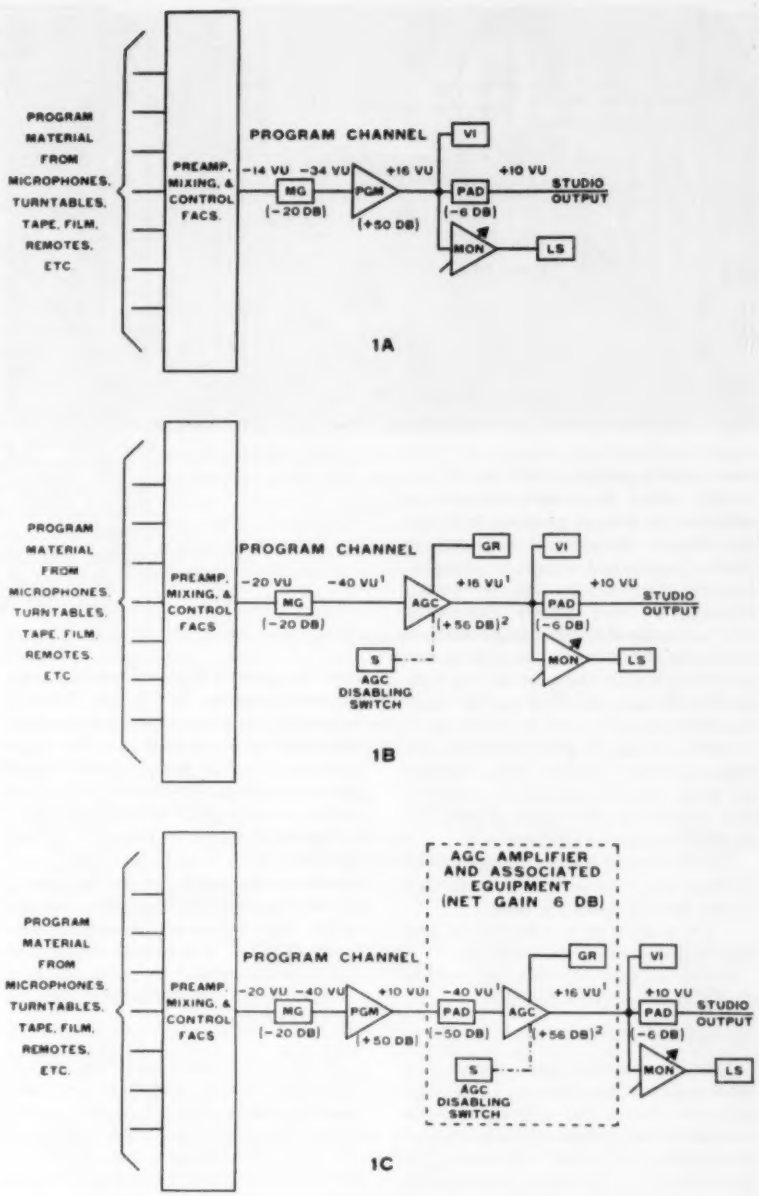
During this investigation, a relatively simple method of improving television audio level discrepancies was found. This new method entails the use in each studio of an automatic-gain-control amplifier with special, carefully chosen gain-reduction characteristics and an associated gain-reduction meter. The new method also entails revising operating techniques to take into account readings of the gain-reduction meter. This new and highly effective approach to balancing television audio levels is described in some detail in the following paragraphs.

Automatic Gain Control

An automatic-gain-control (AGC) amplifier is one which automatically reduces its gain when an audio signal passing through it exceeds a predetermined threshold level. By its fast and automatic action, the AGC amplifier provides an excellent means of holding varying audio signals at a safe level. The associated gain-reduction meter indicates in decibels the amount by which the gain of the amplifier has been reduced to handle an audio signal that exceeds the threshold level.

Such an automatic level-controlling device is of considerable help in controlling widely varying audio levels and helps the audio operator do a better job. However, the automatic level-controlling action, in itself, does nothing to balance loudness differences that do not indicate as such on a volume indicator. On the other hand, the gain-reduction meter associated with the AGC amplifier does provide a new monitoring means which supplies quantitative data that permit the operator to make simple adjustments that will equalize loudness discrepancies.

Assume an AGC amplifier is installed in a studio audio channel and adjusted so that gain reduction takes effect one-half decibel below the volume-indicator reference point. If the audio operator



LEGEND

AGC	AUTOMATIC-GAIN-CONTROL AMPLIFIER
GR	GAIN REDUCTION METER
LS	MONITORING LOUDSPEAKER
MG	MASTER GAIN CONTROL
MON	MONITORING AMPLIFIER
PAD	RESISTANCE ATTENUATION NETWORK
PGM	PROGRAM AMPLIFIER
S	AGC DISABLING SWITCH
VI	VOLUME INDICATOR
(+56 DB)	GAIN OR LOSS OF EQUIPMENT, NORMAL OPERATING SETTING.
+10 VU	PROGRAM LEVEL

1 PROGRAM LEVEL SHOWN IS APPROXIMATE. SEE FIG. 3 FOR EXACT LEVEL.

2 GAIN SHOWN IS GAIN BELOW THRESHOLD OF GAIN REDUCTION.

Fig. 1. Simplified single-line diagrams of studio audio systems. (A) shows a typical system with a conventional constant-gain program amplifier; (B) shows the same system modified to use an AGC program amplifier. At times, it is desirable to retain an existing audio system intact and add AGC by merely introducing an AGC amplifier following the program amplifier. Such an arrangement is shown in (C).

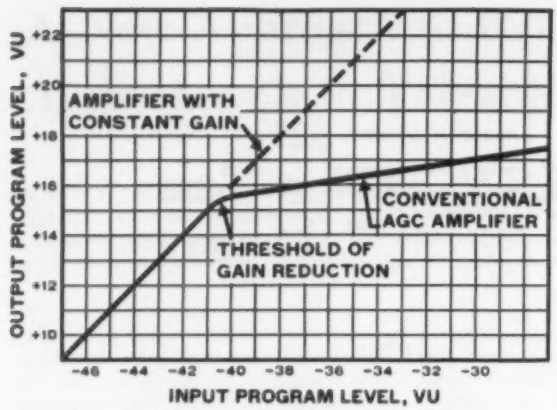


Fig. 2. Characteristics of a conventional AGC amplifier.

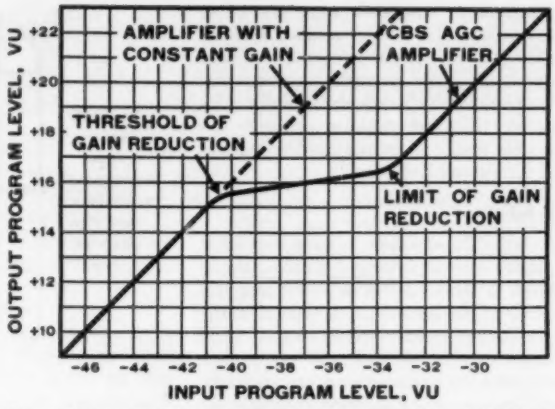


Fig. 3. Characteristics of the CBS AGC amplifier which limit gain reduction to a maximum of 6 db. The levels shown are program levels. Amplifier set-up is accomplished using a sine-wave signal 4.5 db higher than the indicated program levels. Because of the usual 6-db line pad, an amplifier output level of +16 vu is required to deliver a transmission level of +10 vu to the studio outgoing program line. As can be seen, an increase in input level of 7 db is required to increase the amplifier output level from +15.5 to +16.5 vu. This corresponds to 6 db of gain reduction.

now controls program levels in such a manner that 6 db of gain reduction is indicated on normal program material, but no gain reduction is indicated on louder-than-normal program material, loudness discrepancies will be greatly alleviated or even entirely eliminated. This balancing of unequal loudness levels is brought about in two ways. First, the protection against excessive volume indicator deflections afforded by the AGC amplifier gives the operator confidence to transmit normal program material at a higher average volume level. Second, the small amount of resulting compression applied to the signal slightly increases its apparent loudness.

The method of balancing audio levels outlined above reduces itself to the following general operating rules:

1. Use 6 db of gain reduction on program material of normal loudness.
2. Use no gain reduction on louder-than-normal program material.

Application of AGC

Basically, a studio audio system provides facilities for mixing, amplifying, and controlling audio program material from studio microphones, film projectors, transcription turntables, and other program sources. A monitoring loudspeaker is provided for aural monitoring to achieve the desired balance, while a volume indicator provides the visual monitoring means to adjust the studio output to the standard transmission level. A simplified single-line diagram of a typical studio audio system is shown as Fig. 1A.

Adding AGC to Studio Channel. Figure 1B shows the typical studio audio system of Fig. 1A modified to employ AGC. In this case, the constant-gain program amplifier has been replaced with an AGC amplifier together with its associated gain-reduction meter and a switch for disabling the AGC action when desired. The gain of the AGC program amplifier (at program levels below the threshold of gain reduction) has been set 6 db higher than that provided by the constant-gain program amplifier in Fig. 1A. This increase in gain compensates for the 6-db lower gain under conditions of 6-db gain reduction; i.e., the net program channel gain with 6-db gain reduction is the same as the constant-gain system of Fig. 1A.

Figure 1C shows an alternate method of adding AGC to a studio channel with minimum changes to the existing system. In this case, the AGC amplifier follows, rather than replaces, the existing program amplifier. A resistance attenuation pad is used to restrict the AGC amplifier net gain below the threshold of gain reduction to 6 db.

Modified Gain-Reduction Characteristics. Conventional AGC amplifiers have gain-reduction characteristics of the general shape shown in Fig. 2. As this figure shows, the amplifier gain is constant up to the threshold point. From the threshold point on, gain reduction takes place at a rate determined by the slope of the amplifier's input-output curve.

Early in the experiments, it was found that gain-reduction characteristics of conventional AGC amplifiers were not completely suitable for this application. When used, a sudden sharp sound, such as the banging of a gavel, would be followed by a short but noticeable period of low-level audio. This was the result of excessive gain reduction on unanticipated high program peaks. This difficulty was solved by modifying the amplifier characteristics (Fig. 3). With these modified characteristics, only a limited amount of gain reduction (in this case a maximum of 6 db) can be obtained after which the amplifier gain again becomes constant, but with 6-db lower gain. Excessive gain reduction, therefore, can never, intentionally or unintentionally, be applied since the maximum available is 6 db. When this modest limit is placed on the gain reduction, the automatic gain adjustments of the amplifier can never be detected. The amplifier has an attack time of 25 msec and a recovery time of 0.5 sec.

It should be noted that in both conventional AGC amplifiers and the CBS AGC amplifier, the exact point at which the threshold of gain reduction occurs is dependent upon the peak factor of the input signal. The points shown on Figs. 2 and 3 are for average program material.

Operation

When an AGC amplifier has been installed in a studio channel for the purpose of balancing audio levels, a revision of program transmission standards is required. These revised standards must take into account the readings of the new gain-reduction meter which is used along with the volume indicator in controlling program levels (Fig. 4). Revised CBS program transmission standards developed for this purpose are given in Table I.

Additional Benefits

In addition to the improvement in sound transmission already described, the use of gain reduction as detailed above will also provide the following additional benefits:

1. Listeners have sometimes reported that musical portions of programs sound too loud,[9] i.e., music sounds louder than speech. The AGC amplifier together with the revised program transmission standards will also improve, or entirely eliminate, this loudness discrepancy.

2. By automatically controlling unanticipated high program peaks, the AGC amplifier permits the audio operator to do a better audio mixing job.

Conclusion

The method of balancing television sound levels described above has proven so effective that it has been included in all CBS network originating studios in New York, Chicago and Hollywood. This change has effectively eliminated listener complaints. Furthermore, careful listening tests have shown that since these amplifiers were installed and the revised transmission standards put into effect, transitions from sequence to sequence and from program to program are quite smooth with no noticeable change in loudness.

It is believed that the use of AGC amplifiers in the manner described marks another step forward in television broadcasting and represents one more technical advance to make television viewing as pleasant as possible.

This CBS Television Network project was under the general direction of A. B. Chamberlain, Director of Engineering, and R. S. O'Brien, Director of Audio-Video Engineering. It was carried out under the immediate direction and with the active collaboration of Howard A. Chinn, Chief Engineer. Acknowledgment is hereby made to D. R. Wells for his patient and meticulous laboratory work on this project.

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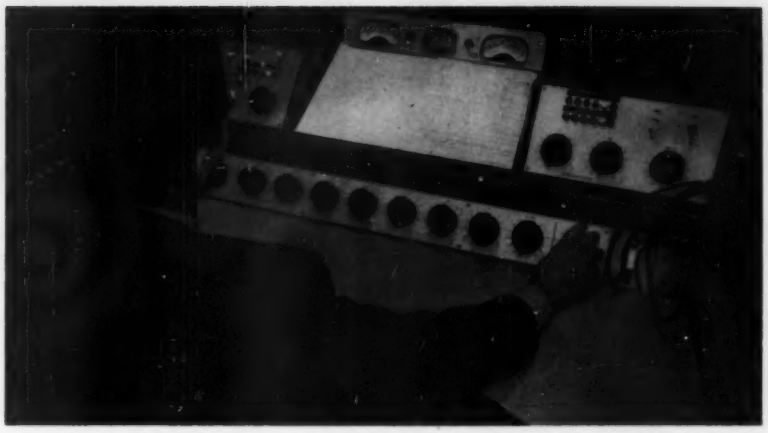

Fig. 4. An audio control console modified for AGC. The meter to the left is the volume indicator; the one to the right is the gain-reduction meter. The gain-reduction meter was formerly a second volume indicator. It has been equipped with dual scales (vu & gain reduction) and can be quickly restored to its original volume indicating function in the emergency audio channel by operation of the small switch at its left. The other small switch to the right of the volume indicator serves to disable the automatic-gain-control when desired.

Table I. Revised CBS Audio Program Transmission Standards for Television.

		VI Peaks	Gain Reduction
A. Speech (live)	1. Normal passages	Peaks of 100	6 db
	2. Low-level passages	Not less than 40	None
B. Music (live) *C. Recorded Programs* (film, transcriptions, and magnetic tape) *D. Commercials* (both recorded and live*) *E. Program Openings and Closings, Station Break Announcements*	1. Normal passages	Peaks of 100	None
	2. Low-level passages	Not less than 40	None
F. Symphonic Music	1. Normal passages	Peaks of 100	None
	2. Pianissimo passages	Must always move VI	None
G. Applause and Audience Reaction		Maximum peaks of 70	None

H. Transition: The transition from a low-level passage to a normal-level passage (or vice versa) must be in steps of not more than 4 db, preferably less (i.e., peaks of 40, then 60, and finally 100, or vice versa). Similarly, two succeeding passages (voice, then music, or voice, then a sound effect, etc.) must not differ in level by more than 4 db, preferably less, even when a contrast is intentional.

I. Peaking Practice: Peaking program material according to the prescribed standards means gaining in such a manner that the maximum VI peaks reach the specified values as frequently as possible without being inconsistent with the program content. It is understood that occasional peaks beyond the prescribed values are unavoidable, but these are to be kept to a minimum.

* Excluding live commercials presented in a conversational manner. These should be treated as in A.

Plastics for Motion-Picture Laboratories

By RODERICK T. RYAN

The use in motion-picture film developing equipment of some of the plastics that have become available since World War II has minimized or eliminated corrosion and contamination problems. This paper outlines the advantages and disadvantages of some of these materials and reports on how they have been employed by laboratories in the Hollywood area. Among the equipment for which they have been found suitable are pipe, fittings and valves; tank linings and construction; and processing machine racks and rollers.

During the past few years, considerable use has been made of plastics in industry. New plastics that have been, and are being, developed have physical characteristics that for certain applications are superior to those of the materials they are replacing. Corrosion and contamination, long the stumbling blocks of photographic equipment designers, have been minimized or eliminated by the substitution of certain plastics. This paper is presented as a progress report to describe some of the motion-picture film developing equipments employing plastics that have been manufactured and put into service in the Hollywood area.

In the construction of processing equipment, the material employed must satisfy certain basic requirements:

(1) It should have a sufficiently high resistance to the most corrosive liquid with which it will come in contact.

(2) Its composition should be such that it will cause no objectionable chemical contamination of the solutions with which it comes in contact that can be detected either photographically or analytically. Temporary effects which disappear with seasoning do not render a material unusable.

(3) Its cost (that is, total cost, including fabrication) must be acceptable.

(4) It must be adaptable to processing equipment and should be easily fabricated.*

Although many materials have been tried for the construction of photographic processing equipment, few have been found that satisfy all these requirements. Prior to the end of World War II, the most satisfactory materials for use in contact with photographic solutions were some of the stainless steels. They are still employed to a considerable extent, but it has been found that with many photographic solutions several plastics that have become available can be substituted with equally good results, and with some solutions, superior results.

One of the most serviceable of these plastic materials is unplasticized polyvinyl chloride. This material is available under several trade names and has been adopted throughout the motion-picture industry in several forms. It possesses the advantage of being resistant to all alkalies, acids and oxidizing agents, in the strength used in photographic solutions, and it can be employed successfully with all the present photographic processes. Its disadvantages are:

(1) It has a thermoplastic characteristic that prevents its use in some applications where high temperatures might be encountered.

(2) It has comparatively low strength, and pipes should be supported every four feet in long runs.

(3) Its high coefficient of thermal expansion must be provided for where the material is employed for tank liners or piping. Otherwise, stresses may be set up which are too great for the material to withstand.

Pipe, Fittings and Valves

Unplasticized polyvinyl chloride is available in the form of pipe, fittings and valves in all standard sizes.

A material called Uscolite† has been used by Airlab in an installation set up for the purpose of testing the feasibility of using plastics in the fabrication of processing equipment. The pipes are formed of extra-heavy wall Uscolite solvent welded with a butt joint. The pipe supports are also made of Uscolite. These and many other uses are illustrated in the papers listed in this paper's Bibliography.

Figure 1 shows part of the rear panel of the Houston Fearless Labmaster.‡ Polyvinyl chloride (PVC) is used for pipe fittings and Cycolac§ for needle valves. Two filter pots are made of rigid PVC.

Figure 2 is a rear view of a machine used for processing Eastman Color Films and manufactured by the Ro-Nan Plastic & Mfg Co.‖ The valves located at the

Presented on April 28, 1958, at the Society's Convention in Los Angeles by Roderick T. Ryan, Motion Picture Film Dept., Eastman Kodak Co., 6706 Santa Monica Blvd., Hollywood 38.
(This paper was received on September 19, 1958.)

* Hastelloy "C," an extremely corrosion-resistant alloy, is an exception to this rule. It is difficult to fabricate, but it is the only metal that has proved satisfactory for ferricyanide bleaches where friction or wearing contact is involved.

† Uscolite CP (styrene-acrylonitrile-butadiene copolymer) and Uscolite RV (unplasticized, unmodified polyvinyl chloride), U.S. Rubber Co., 1230 Ave. Americas, New York 20.

‡ Houston-Fearless Corp., 11801 W. Olympic Blvd., Los Angeles 64.

§ Cycolac (styrene copolymer), Marbon Chemical Div., Borg-Warner Corp., 1926 W. 10th Ave., Gary, Ind.

‖ Ro-Nan Plastic & Mfg. Co., 6161 Cedros Ave., Van Nuys, Calif.

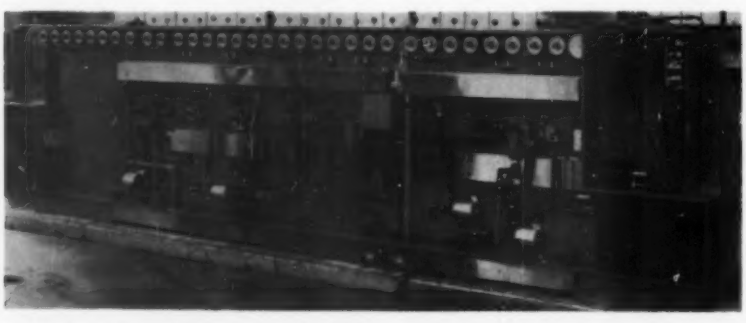

Fig. 1. Rear view of Houston Fearless Labmaster, a color developing machine.

Fig. 2. Rear view of Ro-Nan Plastic and Mfg. Co. color developing machine.

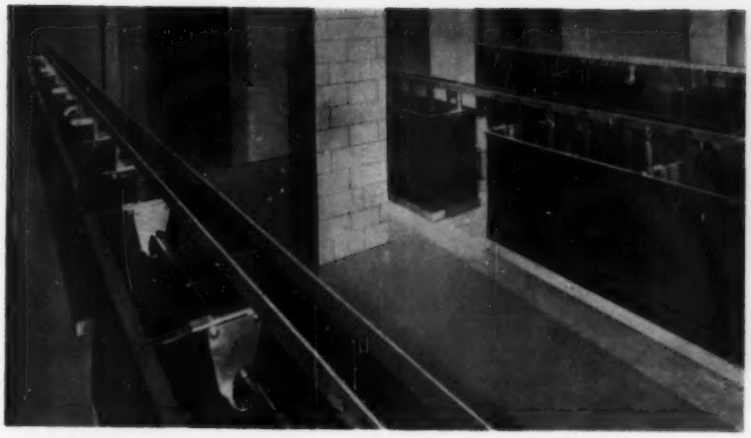

Fig. 3. Developing machine tanks lined with Koroseal, for Technicolor Corp.

Fig. 4. Stainless-steel storage tank (left) placed for comparison beside tank made of rigid PVC. The band around the tank is also made of PVC and is for improving structural strength.

bottom of the machine are Chemtrol¶ ball valves fabricated from rigid PVC. The pipe and pipe fittings running along the back are also rigid PVC. The walls of the machine are marine plywood coated with Fiberglas# and polyester resin.

In a recent survey of 14 laboratories in the Hollywood area, it was found that all were utilizing some rigid PVC pipe in their installations.

In addition to its light weight and chemical resistance, an important factor in favor of rigid PVC pipe is its ease of fabrication. It can be cut with an ordinary handsaw, hack saw, or power saw, and threaded with standard pipe fitting equipment. In threading, no lubricants are needed. For permanent installations it can be chemically welded or hot-air welded. When heated, it can easily be bent or formed.

Tank Linings and Construction

Another rather extensive application of plastics in the construction of motion-picture processing equipment is that of lining or coating developing-machine tanks, mixing tanks and recirculation tanks. This usage has been brought about by the fourfold desire:

(1) To adapt existing processing equipment to handle a new process which employs more corrosive solutions;

(2) To fabricate new containers for solutions that will attack the conventional types of stainless steels;

(3) To fabricate equipment that can be used with ordinary photographic solutions at a lower cost than if stainless steel were used;

(4) To make usable existing stainless-steel tanks that are structurally sound but have suffered from corrosion.

At present in Hollywood, most laboratories use equipment that has been lined or coated for one or more of these reasons. Both flexible and rigid PVC materials have been used for tank liners. In most installations such linings have been applied to processing machine tanks when existing equipment had to be employed with solutions that were more corrosive than those for which the equipment had been originally designed.

Figure 3 illustrates the application of flexible Koroseal** as a liner for processing machine tanks for Technicolor Corp. This installation represents an exception rather than the general rule since the tanks were lined before their initial installation. Rigid polyvinyl chloride sheeting has the advantage of being chemically more stable than the plasticized flexible types, but it also has the disadvantage of being more difficult to install and slightly more expensive.

Another material quite extensively employed for tank linings in local laboratories is Paraline,†† a vinyl plastisol, which can be applied in coatings from $\frac{1}{16}$ to $\frac{3}{4}$ in. thick. Mild steel plate coated with Paraline is incorporated in black-and-white developer tanks, fixing-bath tanks and color-bleach tanks. Applied by the dip method, it has been used for processing machine, mixing and recirculation tanks.

Fiberglas-polyester and Fiberglas-epoxy impregnates have also been used very effectively in lining existing metal tanks, and as a coating for sheet steel in the fabrication of new tanks. These materials are somewhat more difficult to apply than the others mentioned and, therefore, have been somewhat limited in their use. To date, their chief use has been for repairing existing mixing and recirculation tanks damaged by corrosion. Ro-Nan Plastic & Mfg. Co. and Barber-Webb Co. are now making storage tanks of thin sheet steel coated with Fiberglas and polyester resin.

In the construction of new processing equipment, rigid polyvinyl chloride has been used chiefly for processing machine tanks and recirculation tanks of relatively small equipment where the volume and temperature of the solution would not cause physical distortion. However, a large laboratory in the New York area is employing PVC supported by a steel framework for ferricyanide bleach recirculation tanks which are approximately 10 ft deep, proving that larger tanks of this material are practical.

Figure 4 compares a storage tank fabricated from rigid PVC to a similar tank fabricated from stainless steel; note the bracing with an additional PVC band to improve structural strength.

Polyethylene has been used in the fabrication of small laboratory containers. Although very satisfactory for this purpose, polyethylene has not yet been successfully used in the fabrication of other motion-picture processing equipment.

Marine plywood coated with a Fiberglas-polyester or Fiberglas-epoxy impregnate is used more widely and for much larger installations. Marine plywood coated with Fiberglas and a polyester resin offers ease of fabrication, structural strength and chemical resistance not readily obtainable in other material in its price range. Additional features are ease of repair and good thermal insulation. Nine of the processing machines installed in the Hollywood area during the last few years have Fiberglas-coated plywood in their tank construction. Two more are under construction and will be completed shortly.

Figure 5 is the front of the 16mm color developing machine made by the Ro-Nan Plastic & Mfg. Co. The machine employs a marine plywood and a Fiberglas-polyester coating in tank construction.

¶ Chemtrol Corp., 1417 W. El Segundo Blvd., Compton, Calif.

Fiberglas (glass cloth), Owens-Corning Fiberglas Corp., 16 E. 56th St., New York 22.

** Koroseal (polyvinyl chloride), B. F. Goodrich Co., Akron 18, Ohio.

†† Paraline (vinyl plastisol), Barber-Webb Co., 3864 Santa Fe Ave., Los Angeles 58.

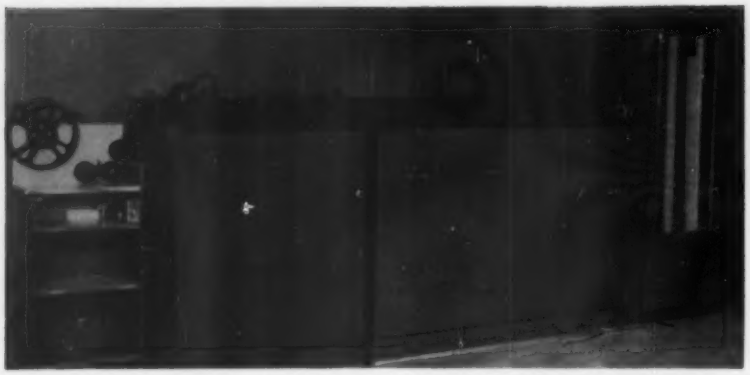

Fig. 5. Front view of Ro-Nan Plastic and Mfg. Co. color developing machine.

Processing Machine Racks

Most of the racks in processing equipment are fabricated from stainless steel, but in some installations other materials have been used very successfully.

One processing machine constructed to process Eastman Color Print Film, Type 5382, has employed rigid PVC pipe to fabricate machine racks. Racks constructed in this manner are as chemically resistant as those of stainless steel and have the advantage of being extremely lightweight by comparison.

Single developing-machine racks have been fabricated from rigid PVC pipe, with joints solvent-welded and pinned on one side. Double developing-machine racks have been made from Uscolite CP pipe and sheeting for the experimental Airlab machine previously mentioned.

Phenol-formaldehyde laminates have been adopted for color bleach racks and for bottom-drive machine gears. This material machines easily and has good mechanical properties and corrosion resistance; however, it requires that proper allowance for ultimate swelling be made, and this is one of the few restrictions that apply.

Processing Machine Rollers

Because of the large number of rollers required in the average-size processing machine, the cost of this item is an important factor along with the machine's durability, dimensional stability and chemical resistance. Originally, wood and hard-rubber rollers were used in processing machines. Some of these were replaced by combinations of wood and stainless steel, and a variety of plastics. Among those in the plastics category are the phenol-formaldehyde laminates previously mentioned for machine racks. These materials have been widely adopted for drive rollers in sprocket-drive machines. More recently polyamides, polyvinyl chlorides and polystyrene compositions have been used.

Figure 6 shows some of the several types of motion-picture processing machine spools now in service. Included in the illustration are nylon, a polyamide and two phenol-formaldehyde laminates or compositions. One of the most popular processing machine roller materials presently used in this area is a Bakelite phenolic.

Because of the many available materials for processing machine rollers, the feasibility of application to a specific manufacturing problem should be the governing factor. At the present time, no one material is outstandingly superior to all others available.

Plastic Paints

Paint layers are often unsatisfactory for processing equipment where they are in contact with solutions. The chief difficulties appear to be poor abrasion resistance and the presence of pinholes.

Plastic paint has been used as a coating on marine plywood for processing machine tank construction. Tanks in one such machine were coated with five coats of Tygon paint.‡‡ It appears that the useful life of such processing tanks would be shorter than if they were made of Fiberglas or Uscolite plastic. In tanks of plywood construction, the presence of just a few pinholes can allow solution penetration that will cause swelling and deformation of the walls.

Bearings

Of the many plastic materials tried for bearings, the Teflon§§ composition laminates and phenol-formaldehyde laminates seem to show most promise. By breaking up the area of the bearing surface into a series of smaller areas, these materials have less tendency to gall and, therefore, show less wear. A new bearing composition that has become more widely used recently is Teflon-Fiberglas-molybdenum disulfide.[|||] This composition has a low coefficient of friction either wet or dry.

‡‡ Tygon (vinyl-chloride resins), U.S. Stoneware Co., Akron 9, Ohio.

§§ Teflon (tetrafluoroethylene resins), E. I. du Pont de Nemours & Co., Inc., Wilmington 98, Del.

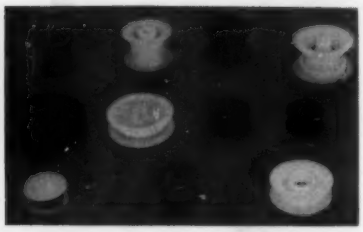

Fig. 6. Developing machine rollers for processing motion-picture film.

Acknowledgments

I wish to thank John R. Turner, Eastman Kodak Co., and also the Barber-Webb Co., Airlab, Houston-Fearless Corp. and Ro-Nan Plastic & Mfg. Co. for their assistance and illustrations.

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10. Irwin A. Moon and F. Alton Everest, "A film processing machine of flexible characteristics," *Jour. SMPTE, 67:* 758–762, Nov. 1958.

||| Teflon-Fiberglas-molybdenum disulfide, Dixon Corp., Bristol, R.I.

Significant Developments in TV Studio Lighting Layouts

By ROLLO GILLESPIE WILLIAMS

Certain problems must be overcome to use successfully dimmers of the silicon-controlled rectifier type in TV studios. A specially designed dimmer has been developed and made available economically to allow a greater number of dimmers in a studio installation. This increases the need for more flexible preset systems. A new punch-card type of "automatic infinite preset" system is described. It can be arranged to control position, angle, focus and spectral quality of studio lights in addition to circuit selection and control of lighting intensity. Lighting layouts can use fewer units; and dimmers can be located on, or adjacent to, the lighting fixtures. Backgrounds of luminous color can be accurately controlled for frequent changes of color and brightness.

ELECTRONIC dimmer systems using thyratron tubes have been controlling studio lighting loads in this country for many years. These systems very frequently employ a C-I Dimmer, which uses a pair of thyratron tubes back to back, to control lamp loads up to 8 kw per dimmer.

The development of semiconductor devices includes a silicon-controlled rectifier which can be used as a substitute for thyratron tubes with a significant reduction in the size, heat and audible noise of electronic dimmers. Also, tube replacement cost is eliminated and efficiency improved. Consequently, it is not surprising that the silicon-controlled rectifier type of brightness control is heralded as revolutionary in the field of dimmer design and in its promise of low cost.

Studio-Lighting Dimmer Problems

However, a number of problems, apart from dimmer characteristics, must be overcome before the silicon-controlled rectifier type of dimmer can be considered suitable for TV studio work. Since design, construction and performance characteristics are affected, it is proposed to discuss briefly some of these problems.

"Video hash" and audio interference may take place, lamp filaments may hum, and diode-controlled switches in other equipment may be affected if wavefront "spikes" are not smoothed or eliminated, and current rise-time modified, by suitable circuitry and accessories. Because of the one-half cycle response of the rectifier, ordinary fuse or circuit-breaker protection does not act quickly enough to protect it from damage by short circuit. Equally serious is the heavy surge of current during several cycles, caused by switching a large incandescent filament lamp on at full voltage. For example, the inrush current of a 5000-w lamp is in the order of 500 amp and about 20 cycles are necessary to establish the normal lamp current. The C35B (or C35B X 510) silicon-controlled rectifier (G.E.) used in dimmers has a present peak one-cycle rating of 150 amp. Unless the rectifier response can be delayed from its normal one-half cycle response to the several cycles needed for the inrush to come within the normal rating of the rectifier, it will destroy the junction in the rectifier. Such a time-delay device can be incorporated; for example, it may be placed in each jack of a cross-connect patch panel to prevent "hot" patching of existing lamp loads onto dimmers in the "up" position. However, this affords no protection if a load is already connected to a dimmer but is switched on at a point beyond the dimmer when the latter is "full up," or if lighting units are connected to "hot" pigtails in the studio while the dimmer is "full up." Of course, amp traps, which by burning out first prevent destruction of the rectifiers, can be used. Unfortunately, with the present I^2T rating of the C35B X 510 rectifier,* 20-amp traps are the largest that will afford protection under these conditions (15-amp amp traps for the C35B rectifier). As far as the author knows, amp traps of this size are not suitable for protecting two back-to-back silicon-controlled rectifiers controlling 4–5 kw of lighting load.

Thus, while it is possible to use a pair of C35B or (C35B X 510) silicon-controlled rectifiers to dim loads of 4–5 kw, it is difficult to protect them from destruction if the load is switched on at a point beyond the dimmer when the dimmer is in the "full up" position, or if the load is connected to the dimmer while it is "full up" without time-delay devices at each possible point of connection, or if there is a short circuit.

Advantages of New Electronic Dimmer

Dimmers must be designed to avoid "drift" so that lighting values are constant for given control settings, and do not vary from hour to hour or from day to day. Especially when cross-connect systems are used, it is desirable that all dimmers of the same size in an installation give approximately the same degree of response to control settings.

Now, having briefly touched on some of the problems, let it be said at once that they can be overcome by means of a new 5-kw C-Core Dimmer. The dimmer is necessarily more complex than the simple setup needed to provide just a good dimming performance, but its size, weight and performance characteristics assure important advances over previous types of remote-control equipment. Voltage drop is small. There is an infinite loading ratio, and the dimming curve is even better than that obtained with thyratron tube dimmers. It is possible to dispense with voltage boosters and certain auxiliary equipment previously needed with electronic dimmer systems. Within the load capacity of the dimmer, the new type is likely to cost less than the previous types of electronic dimmer equipment mentioned.

Another important development is a new application of an old principle of circuitry whereby auxiliary equipment has been developed to handle only one thyratron tube or silicon-controlled rectifier to control the full sinusoidal wave of dimmer output. The embodiment of this method in the C-Core Dimmer provides a further reduction in cost with only a slight increase in size and weight. Performance characteristics are virtually the same, except that the loading ratio is limited to 10 : 1. In television work, the saving in cost is likely to be much more important than the limitation of loading ratio.

Thus a new electronic dimmer is available that at present will handle loads up to 5 kw (and in the near future loads of larger magnitude) at a cost much lower than has heretofore been possible with electronic dimmer equipment. As a result, a greater number of dimmers may be used in a TV studio and this in turn will advance the art of lighting and create greater opportunities for lighting skill.

Presented on May 6, 1959, at the Society's Convention in Miami Beach by Rollo Gillespie Williams, Century Lighting, Inc., 521 West 43 St., New York 36.
(This paper was received on May 7, 1959.)

* This is currently rated at 170 amp^2 × sec, compared to 108 for the 20-amp and 169 for the 25-amp amp traps. In view of allowable tolerances the latter rating is too close to that of the rectifier to provide adequate protection.

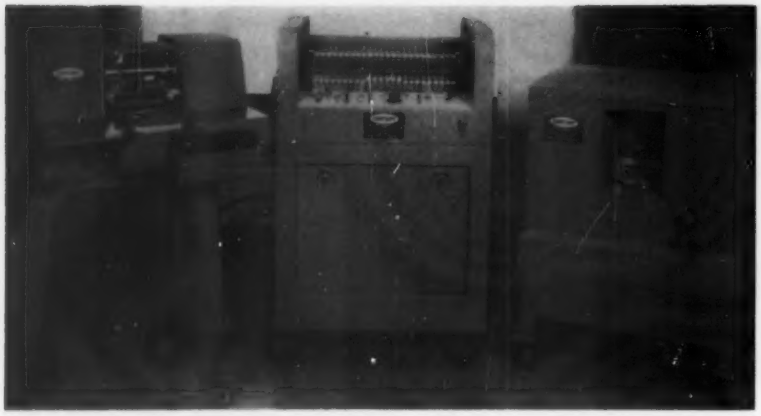


Fig. 1. Three of the control components of the Century "automatic infinite preset" system, from left to right: (a) card-punching machine; (b) operating console with master controls; and (c) card-reading machine. In this instance the matrix is housed in the cabinet under the console.

Infinite Preset System

To make full use of such a dimmer system, it is necessary to have preset facilities. At the present time, two-scene, five-scene and ten-scene preset systems are in use. However, even a ten-scene preset imposes limitations on the use of lighting changes, and it is desirable to be able to set up for an unlimited number of lighting changes. This brings up the desirability of an "infinite preset" system which can be set up quickly by the operator. Hitherto it has been necessary to manipulate a preset control for every circuit in each preset scene; this procedure, of course, is time-consuming. Punch-card systems have been made available in which the operator can either mark up or "punch" cards by hand, so that he makes his own punch card, recording all settings in a particular scene. But this method also takes up valuable time and is a limiting factor in the use of a large number of lighting changes in the show.

An *automatic* "infinite preset" system has now been developed by Century Lighting, Inc., which overcomes these limitations and reproduces all circuit and brightness selections with an accuracy and speed heretofore impossible. The conventional preset equipment and scene selectors are replaced by electrically operated card-punching and card-reading machines.

When the required brightness values for the various lighting circuits have been determined at rehearsal by manipulation of the manual control console, all that is necessary to record the whole arrangement is for the operator to press a single pushbutton. If the card-punching mechanism is already switched on, it then "reads" all the manual settings on the console and translates them into a digit code on a punch card. The entire operation for a 90-circuit system requires less than 15 sec.

After all the light cues and scenes have been translated into punch cards, these are stacked in the card reader. The first card is "read" into the "upper" memory, the second into the "lower" memory, thereby producing a two-scene preset arrangement — one for the control of the lights and one into which the fader will shift control. As soon as control has been transferred to scene 2, the card reader "reads" scene 3 into the "upper" memory, replacing scene 1. This can be done in approximately $\frac{3}{4}$ sec, enabling lighting cues to be operated in sequence at the rate of 100/min with complete accuracy.

When the punching of a card is completed, a new card is automatically placed in readiness for the next recording. The code which is punched into a card corresponds to digital translations of the circuit intensities.

If a lighting change is required after the lighting has been set up by the card-reading mechanism, any circuit can be manually changed to a new value by transferring circuit control to the manual controller in the console. Additional means are provided whereby the manual means may first be set at an intensity corresponding to the one provided by the card reader, so that in changing over control from card reader to manual, there is no alteration in the lighting intensity of the circuit.

During a rehearsal period, it may be that after the intensity readings are reproduced by the card-reading machine, it is desired to make a lighting change, so means are provided for corrections. Alternately, if a lighting change is required after the card is punched and certain manual controls have been reset, it is not necessary to reset all other controls in order to punch a new card. Instead, the old card is fed into the reading machine and the lighting setup is corrected as desired on the console, after which a new card is made by pushing a single button.

The automatic preset system will perform any function required and reproduce any setup which has been made for it. However, the time allowance for changing from setting to setting is left in the control of the operator who is provided with the means of having either a $\frac{3}{4}$-sec interval between changes or as long a period as he may require. The lighting from one setting can be merged into the following arrangement at any desired speed.

Control Apparatus of System

This new "infinite preset" system normally comprises four pieces of control apparatus, in addition to the dimmer banks. These are (a) the card-punching machine, (b) the manually operated console with master console, (c) the card-reading machine, and (d) the switching and translating matrix. Three of these pieces of apparatus are illustrated in Fig. 1, in which the console is seen in the center and the card-punching machine on the left. The matrix equipment in this instance is housed in the cabinet under the console.

Figure 2 is a close-up view of the console for a 24-way dimmer installation. The various control pushbuttons, switches and faders are shown. The circular dial seen in the center of the control desk, operated in conjunction with a rotary switch, is calibrated to match values on the scales operated in conjunction with the manual circuit brightness controls. It enables the lighting value of any dimmer circuit to be read at any time while the lighting is in operation, even when under the control of the card-reading machine. Thus to find the intensity for use, say, on Dimmer 20, the rotary switch is turned to position 20, and the value of the lighting intensity on that particular circuit can be read on the dial. This arrangement enables any particular control to be set in advance to give the same value as the lighting before transferring to manual operation; thus transfers can be made without any visual change in lighting intensities.

Figure 3 shows the card-punching machine with a stack of punch cards in position, ready for transmission into the machine for punching.

Both the card-punching and card-reading machines are less than 30 in. in width and remain this size, regardless of the number of dimmers controlled by an installation. A single punch card will record all necessary information concerning 90 dimmer circuits. When the installation has more than 90 dimmers, then two or more cards are employed. Thus, if the "infinite preset" system is used for 150 dimmers, two cards will be used and the time to punch both of them would be about 30 sec. The time

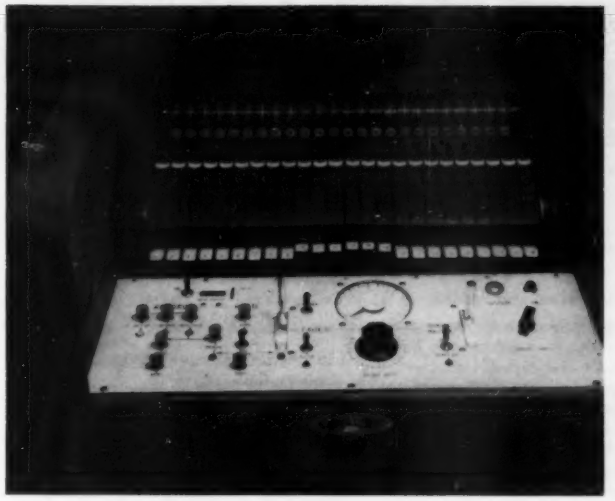


Fig. 2. Close-up of the manually operated console for 24 dimmers, showing the various control buttons, switches and fader for the punch-card "automatic infinite preset" system.

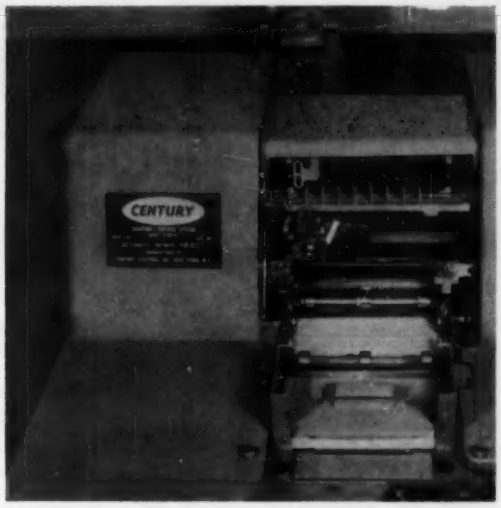


Fig. 3. The card-punching component of the "automatic infinite preset" system. A stack of cards is shown in position ready for transmission into the machine for punching.

required to "read" both cards would be approximately 1½ sec.

The "infinite preset" system can also be utilized to control the movements of electrically operated mechanisms such as spotlights which can be panned, tilted, focused, raised and lowered, etc., by means of remote-controlled operation. Thus height, angle and focus of spotlights can all be recorded on the punch mechanism and read back from cards.

It might in fact be said that any form of electrical mechanism can be arranged for control by this system. Hence color filter changes, spotlight positioning, circuit selection and brightness control can all be recorded on the same punch cards and reproduced in sequence.

This will have a far-reaching effect on lighting unit layouts. When a single unit can be changed in position, angle and focus by remote control, fewer units normally will be required. This, in turn, will affect the electrical layout, and it may be found better to locate the dimmers on, or adjacent to, the lighting units rather than in a dimmer bank at a distance.

Application of System to Color Changes

A paper by the author in the July 1957 *Journal* described "A New Variable Luminous Studio Wall." This wall has been found very useful for Chroma-Key work, as well as for background effects. The control for a four-color system of this nature by the "infinite preset" system will greatly expand the opportunities for using the color wall. Since very carefully determined combinations of colors can be accurately recorded, and reproduced in ¾ sec, any number of color changes can follow each other at any desired speed. When dealing with four-color lighting systems there are four, instead of one, brightness controls to operate for each piece of four-color equipment, and the need for preset facilities is therefore increased. When using color-change lighting, a great number of presets are required to record every desired variation, and here the "infinite preset" system will be of very great value. Also, when the color lighting sequence is being set up at rehearsal, each desired effect can be accurately recorded in a few seconds on a punch card, providing for more extensive use of color-changing effects.

In another paper before this Society, the author referred to the desirability, in his opinion, of "modifiable white light" for color work (*Journal*, December 1955). Such light would be obtained from lighting units, each of which contained a primary source of white light and three secondary sources of colored light (e.g., red, green and blue). The four sources would be blended by means of dimmer controls and would provide any desired spectral quality of light at any required intensity. Among other things, this method would overcome the drawback of changed color quality, which is experienced with dimming incandescent filament lamps.

The "infinite preset" system would overcome the operational difficulties involved with frequent adjustments of lighting quality, and when picture color rendition requires an immediate and unrehearsed adjustment, it can be made with the "over-ride" means, which allows manual operation of any controls without disturbing the rest of the setting.

The end result of the "infinite preset" system is to widen the art of lighting and to enhance the capabilities of people responsible for lighting. It does not tend toward mechanization of the art, but removes many shackles that limit full expression by the individual.

news and reports

86th Convention • October 5-9 • Statler Hilton Hotel, New York

Now is the first of August: The papers sessions are being organized from Author Forms submitted at deadline of July 27; the equipment exhibit arrangements are well advanced; and all the local arrangements for putting on the program and show are in preparation.

The theme of the Convention — *Motion Pictures and Television in the Space Age* — has elicited enthusiastic response from authors and exhibitors, as listed in the July *Journal*. Initial plans are that sessions on "Space Technology and Image Sensing" will be held on Tuesday, October 6, and that evening will be the occasion of the annual presentation of SMPTE Awards. Edgar M. Cortright, Chief of the Advanced Technology Program, National Aeronautics and Space Administration, will be the guest speaker. His subject will be "The Space Age."

The guest speaker at the Get-Together Luncheon, Monday Noon, will be Edward P. Curtis, Vice-President, Eastman Kodak Company.

J. Paul Weiss, 86th Program Chairman, is now reminding all authors that their next deadline is "on or before September 4" for at least reading copies or oral drafts of their papers to reach the Program Chairman (and two copies to Society headquarters, for the Editor and the Publicity Director).

Symposium on Film Steadiness

Announced in the July *Journal*, this symposium has been organized by Gordon Chambers as follows:

"American Standards in Their Relationship to Steadiness" by Deane R. White
"Pin Registration" by A. C. Robertson
"Demonstration of the Principle of Cancellation" by A. C. Robertson
"Cancellation" by John A. Maurer
"Pin Locations in Special Effects Mechanisms to Effect Steadiness" by John P. Kiel
"Projector Steadiness" and "TV Projector Steadiness" are tentatively scheduled.

Test Film Resales

It has come to the attention of the Society that a quantity of several types of SMPTE Test Films which were produced some years ago, are now being offered for resale. Due to the fact that the physical characteristics and the useful life of film may be affected by the conditions and length of storage, the Society can make no representation as to the conformance of such films with established Society standards.

Equipment Papers Session and Exhibit

The success of "Equipment Papers and Demonstrations Session" — too new to be traditional; too old to be experimental — is definitely assured with enthusiastic participation. Some changes in scheduling since publication of the July *Journal* have put this session on Wednesday morning.

Exhibitors whose equipments are now scheduled for display at the Statler Hilton Hotel during Convention week are:

Animation Equipment Corp.
Arriflex Corp. of America
Bausch & Lomb Optical Co.
Bell & Howell Co.
Camera Equipment Co.
Camera Mart, Inc.
Cine Speed Inc.
Florman & Babb, Inc.
Karl Heitz, Inc.
Houston Fearless Corp.
JM Developments, Inc.
Macbeth Instrument Corp.
National Cine Equipment, Inc.
Neumade Corp.
Precision Laboratories
Prestoseal Mfg. Corp.
Rapid Film Technique, Inc.
S.O.S. Cinema Supply Corp.
Time Automated Mfg., Inc.
Vicom, Inc.

Arrangements

Immediate plans for all staging and services details for the Convention are under control by R. C. Rheineck who brought his entire Local Arrangements Committee to meet with Convention Vice-President Reid H. Ray on July 31. The Fall Convention Arrangements Committee is:

Local Arrangements Chairman: *R. C. Rheineck*, CBS News
Vice-Chairman: *E. M. Warnecke*, Eastman Kodak Co.
Administrative Assistants (Members of the New York Section Board of Managers): *V. J. Duke*, NBC; *J. W. Kaylor*, Movielab Film Labs; *P. M. Keane*, Screen Gems; *J. L. Koushouris*, CBS.
Awards Session: *Charles J. Hirsch*, Hazeltine Research Corp.
Banquet: *Saul Jeffee*, Movielab Film Labs
Exhibits: *W. J. Reddick*, W. J. German, Inc.
Hospitality: *C. W. Carpenter*, Technicolor Corp.
Hotel Arrangements: *B. F. Perry*, Westrex Corp.
Ladies Program: *Mrs. R. C. Rheineck and Mrs. E. M. Warnecke*
Luncheon: *Arthur J. Miller*
Membership: *J. T. Dougherty*, E. I. du Pont de Nemours & Co.
Projection, Public Address and Recording: *R. E. Buescher*, RCA
Publicity: *Charles Austin*, Mitchell Camera Corp.
Registration: *W. H. Metzger*, Ansco
Transportation: *C. F. Lo Balbo*, Philip A. Hunt Co.

Proposed Bylaws Amendments

Two brief amendments to the Society's Bylaws have been duly considered by the Board of Governors at their meeting on June 26th and are proposed here for consideration by the voting members of the Society.

The proposals will be voted upon at a business meeting scheduled for the opening sessions of the 86th Convention to be held in New York on October 5. If approved, the amendments will become effective immediately.

Present members of the Revisions Committee on Constitution, Bylaws and Administrative Practices of which Wilton R. Holm is Chairman are: Don M. Alexander, Herbert Barnett, Gerald G. Graham, Barton Kreuzer, John W. Servies, S. P. Solow, Ethan M. Stifle and Edwin W. Templin.

The revisions which are being proposed are with respect to Bylaw I, "Membership," Sec. 3(a); and Bylaw VIII, "Society Elections," Sec. 1. These two portions follow, printed in the presently proposed form and with deleted or superseded portions indicated by brackets. The Constitution and Bylaws were last published in the April 1958 *Journal*, Part II. Reprints are available from Society Headquarters.

BYLAW I

Membership

Sec. 3(a). Honorary membership may be granted upon recommendation of the Honorary Membership Committee when confirmed by a three-fourths majority vote of those present at a meeting of the Board of Governors. [Delete the following: *and then by a four-fifths majority vote of all voting members present at any regular meeting or at a special meeting called as stated in the Bylaws.*] An Honorary member shall be exempt from the payment of all dues.

BYLAW VIII

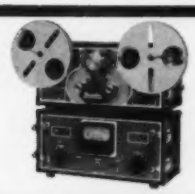
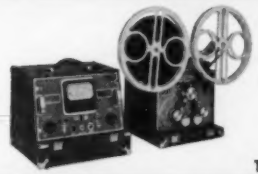
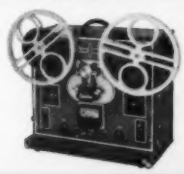
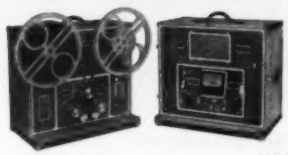
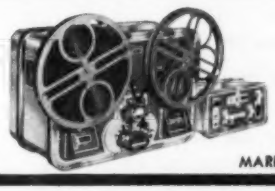
Society Elections

Sec. 1, paragraph 3:

Not less than 60 days [instead of *three months*] prior to the Annual Fall Meeting, the Board of Governors shall review the recommendations of the Nominating Committee, which shall have nominated suitable candidates for each vacancy.

*How to select a recorder to start your MAGNASYNC-MAGNAPHONIC SOUND SYSTEM

Sound Equipment Checklist

		LIGHTWEIGHT	MEDIUM WEIGHT	16 MM FILM	17½ MM FILM	35 MM FILM	REWIND	FOOTAGE COUNTER	POWER AMPLIFIER	MONITOR SPEAKER	TORQUE MOTORS	PLUG-IN AUDIO	PUSH BUTTON CONTROL	REMOTE CONTROL	SLIDE-WIRE POTS	FILM MONITOR	SYNKINETIC MOTION	PLUG-IN HEADS
 X-400	When lightweight portability is a must the 27 lb. X-400 Type 1 is the answer! Another reason so many producers choose this machine is that it is genuinely professional, and yet, surprisingly economical! From $985.	X		X			X	OPTIONAL	OPTIONAL	OPTIONAL						X	X	OPTIONAL
 TYPE 1	The Type 1 is a miniaturized version of the Type 5. Low power consumption and extreme portability has made this 39 lb. unit a popular selection for remote location production by leading professional motion picture studios. From $1360.	X		X	X		X	X	X	OPTIONAL		X				X	X	OPTIONAL
 TYPE 15	The X-400 Type 15 is designed for the man who wants everything in one case . . . playback amplifier, monitor speaker, footage counter and torque motors. You can be proud to have this machine represent you on any sound stage! From $1385.		X	X			X	X	X	X	X					X	X	OPTIONAL
 TYPE 5	The most popular magnetic film recorder in the world is the Type 5! With this unit and all its operational conveniences, you are definitely in the "major league." The Type 5 owner always starts his pictures with a special feeling of confidence in the realization that he has allowed no compromise in the selection of equipment. From $1570.		X	X	X	X	X	X	X	X	X	X				X	X	OPTIONAL
 MARK 1X	There is nothing on the market that compares with the remarkable Mark 1X. This unit is in a class by itself . . . with push-button remote controlled relay functions, plug-in audio elements and all the "extras" that make for flawless recording under the most adverse conditions. From $2145.		X	X	X	X	X	X	X	OPTIONAL	X	X	X	X	OPTIONAL	X	X	X

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Advance Program

The September *Journal*, planned to be mailed in the second week of the month, will have the Advance Program of papers with abstracts arranged in sessions as expected for final programing.

Postal Announcement

The usual type of postal announcement is scheduled to go to all members in the last week of this month. It will give the format of the Convention by sessions as planned by mornings, afternoons and evenings. Also included will be a schedule and reservation card for the Statler Hilton Hotel and also information for Advance SMPTE Registration.

Members are urged to take advantage of the Advance Registration blank and thereby avoid a possible wait in line at the Registration Desk on the busy first day of the Convention.

Rates at the Statler Hilton Hotel are:

Single rooms: $8.00, 8.50, 9.00, 9.50, 10.00, 10.50, 11.00, 11.50, 12.00, 12.50, 13.00, 13.50, 14.00 and 14.50.

Double rooms: $11.00, 11.50, 12.50, 13.50, 14.50, 15.50, 16.50, 17.50, 18.50, 19.50, 20.50, 21.50, 22.50 and 23.50.

Twin-bed rooms: $15.00, 15.50, 16.50, 17.50, 18.50, 19.50, 20.50, 21.50, 22.50 and 23.50.

Suites: $38.00 and $40.00.

Reservations should reach the hotel not later than two weeks ahead of arrival date.

Fifth International Congress on High-Speed Photography

Since the First International Congress, which was organized by *John H. Waddell* and sponsored by the SMPTE in Washington, D.C., in 1952, there have been three Congresses, of increasing scope and significance: in Paris (1954), in London (1956) and in Cologne (1958). Research and development in the science of high-speed photography and the tremendous growth of governmental and industrial activity in this area have stimulated interest in the international forums that these Congresses provide to such an extent that they have now become major international meetings, in which governments as well as private users and manufacturers participate.

The Fifth Congress, to take place at the Sheraton Park Hotel, Washington, D.C., October 16–22, 1960, under the sponsorship of the SMPTE, will comprise a full week of technical sessions, with allowed time for attendance at international industrial and governmental exhibits and demonstrations of high-speed instrumentation systems and equipments. In planning the Congress, the Society is giving due emphasis to the important role allotted to photographic equipments and processes by the government and its contractors.

Simultaneous interpretation of the three official languages — English, French and German — will be provided through individual wireless headset radio receivers with channel selectors.

Prior to the Congress, summaries of the technical papers to be offered will be distributed to registrants, delegates, speakers, session chairmen and institutions that have interest in high-speed photography.

The organization of sessions is now in progress and topic chairmen are in process of appointment. Supervising this work in an overall capacity is the Chairman of the Congress, *D. Max Beard*, 10703 E. Nolcrest Dr., Silver Spring, Md., assisted by Associate Papers Chairman *Richard O. Painter*, General Motors Corp., Proving Ground Section, Milford, Mich. National delegates will solicit and forward papers from the various countries participating and these will be coordinated by *J. S. Courtney-Pratt*, Room 1D-449, Bell Telephone Laboratories, Inc., Murray Hill, N.J.

Dr.-Ing. Hubert Schardin, Rosenstrasse 10, Weil am Rhein, Germany, who was Chairman of the Fourth Congress, is Deputy Chairman of the Fifth. He will assist in the work of coordinating contributions from Europe, along with the able assistance provided by the National Regional Papers Chairmen of the Society throughout the world.

Sessions will open with short films related to photographic instrumentation subjects. Some activities are now preparing films for this purpose and contributions are expected from all parts of the world. The chairman for short film subjects is *James A. Moses*, 1202 Oberlin Dr., Bucknell Heights, Alexandria, Va.

Author Forms for the Congress will soon

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- **Effect!**
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be available from various Chairmen and Society Headquarters. The initial requirement is expected to be a two-page summary of the author's work which is the basis of the proposed paper. These summaries will be reviewed by a special Review Board for suitability for the Congress sessions. The final proceedings of the Congress will be published by the Society in English with abstracts in the three official languages.—*D.C.*

Education, Industry News

Two sessions of technical papers on photographic instrumentation have been arranged by a new technical division for the Instrument Society of America's 14th Annual Instrument-Automation Conference and Exhibit to be held in Chicago, Sept. 21–25. Donald B. Prell, Vice-President of the Benson-Lehner Corp., Los Angeles, is Director of the new division. Formation of this division brought the total of technical divisions within ISA to 24. Papers scheduled for presentation at the ISA Conference include: An Introduction to Photographic Instrumentation Engineering, by A. H. Katz; Sensitized Materials for Use in Photographic Instruments, by Fred C. Eisen; The State of the Art in Photographic Reduction Techniques, by Benjamin E. Billups; Survey of Semiautomatic Record Readers, by Earl G. Raguse; General Motors Proving Ground and Photographic Instruments, by A. H. Kelly; In-Flight Measurement of True Angle of Attack Using the Photographic Method, by S. R. Colletti; How to Photograph a One-Window Bubble Chamber by Duane U. Norgren; and Some Photographic Instrumentation Used in Propulsion Research at the NASA Lewis Research Center, by R. E. Tozier.

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The Audio Engineering Society will hold its Eleventh Annual Convention and Professional Equipment Exhibit Oct. 5–9 at the Hotel New Yorker, N.Y. Plans include three technical sessions each day from 9 A.M. to 8 P.M. Papers will cover theories, developments and recent achievements in the audio field. An extensive discussion of stereophonic sound is scheduled. Chairman of the Convention Committee is Harry L. Bryant, c/o Radio Recorders, 7000 Santa Monica Blvd., Hollywood 30.

The Biological Photographic Assn. will hold its 29th Annual Meeting Aug. 31—Sept. 3 at the Sheraton Mount Royal Hotel in Montreal. Speakers will describe research and administrative developments in the use of photography and motion pictures at their particular medical and dental schools, hospitals, research institutions or science centers. Motion-picture awards will be announced in the categories of professional, institutional and sequence films. Further information is available from John L. Linder, Canadian National Railways, Photographic Branch, 884 St. James St., W., Montreal 3, Que.

Finland has become the thirteenth country to affiliate with Eurovision. The announcement was made June 6, on the fifth anniversary of the network's first international exchange of programs. Finland has been largely dependent upon TV broadcasts from Estonia. The twelve countries now a part of Eurovision are: Austria, Belgium, Great Britain, Denmark, France, Germany, Italy, Luxembourg, Monaco, The Netherlands, Sweden and Switzerland.

Eye, Film and Camera in Color Photography, by Ralph M. Evans, is scheduled for publication in September by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16. The new book, which deals mainly with the scientific and creative aspects of still color photography, promises enduring value as a popularized (but nonetheless sound) scientific treatise and a book of exciting literary qualities. This book will take a worthy place beside Mr. Evan's earlier book, *An Introduction to Color* (published in 1948), which is regarded as a classic work in the field. Advance proofs of the new book indicate that it will be useful as a textbook or supplementary reading for courses in photography at colleges and graduate schools and that it will probably find a large audience among young professional photographers and aspiring amateurs as well as alert individuals who have a wide range of interests. It will appeal to an audience with slightly different, although related, interests compared with those who so warmly welcomed the Society's publication, *Elements of Color in Professional Motion Pictures*, which benefited from Mr.

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Evans's earlier work. Mr. Evans has an international reputation as an authority on Color. He was recently presented with the Godlove Award of the Inter-Society Color Council (*Journal*, p. 258, Apr. 1959). He is the author of several papers which have been published in the *Journal*. Those who have heard and seen Mr. Evans's lectures at Society Conventions will find many interesting principles demonstrated in his new book.

TV & Film Production Data Book is a new work by Ernest M. Pittaro soon to be published by Morgan & Morgan, Inc., 101 Park Ave., New York 17. The 448-page book, with illustrations of products, procedures, specifications, instructions, data and tables, is intended to provide instant answers to thousands of questions asked daily by planning, supervisory and production staffs. Besides the many tables, covering TV station and set data as well as every aspect of motion-picture shooting and projection, the book will include specifications and working data on the leading types of U.S. TV production equipment, operating instructions and specifications for motion-picture cameras and related equipment of all kinds, and information on general studio equipment. There will also be a Manufacturers Directory.

An SMPTE member of many years standing, Ernest Pittaro has long been known for his professional accomplishments, especially in the areas of animation, stop-motion and special effects. He has contributed many book reviews to the *Journal* and a useful reference list of books and articles on animation which was published in the *Journal* in September 1951 (p. 282).

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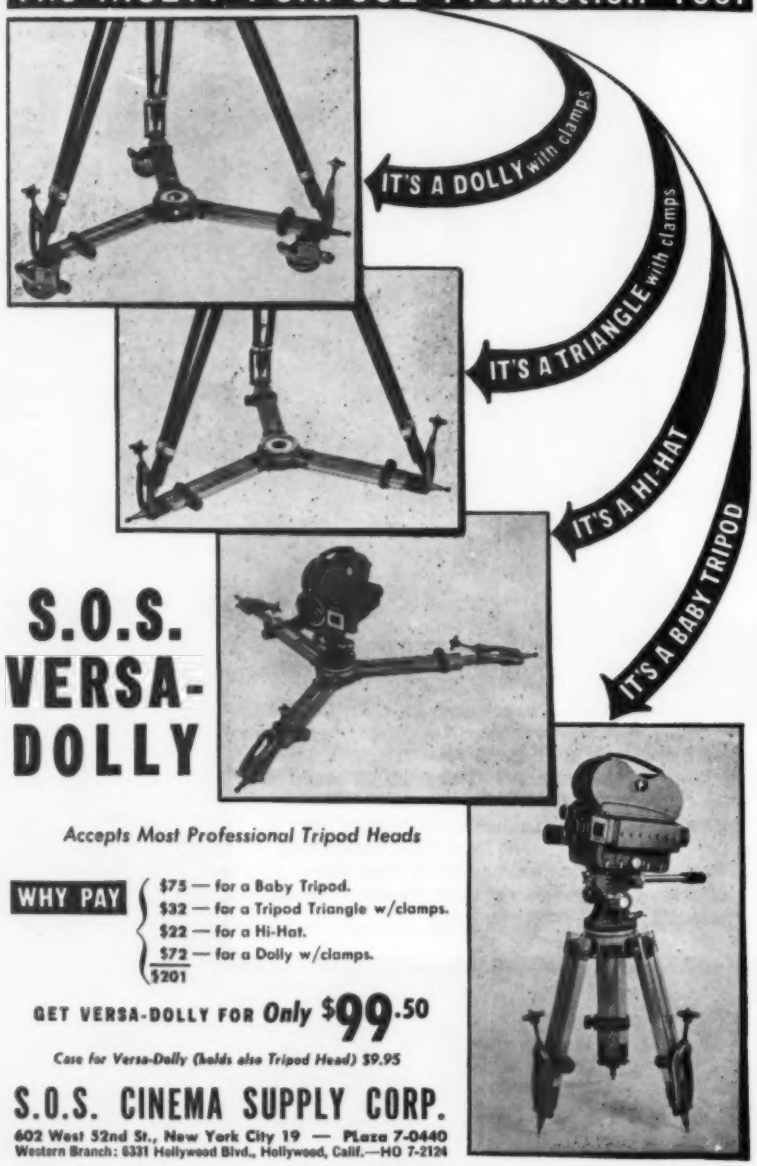

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section reports

The Chicago Section met on June 16 in the Beaubien Room of the Prudential Building in Chicago with a capacity attendance of 130. The program, concerned with "Animation Techniques," included papers covering both equipment and procedures.

Richard W. Kleidon of Kleidon Animation Studios in Chicago discussed "Basic Animation Techniques." He described the various types of animation materials and the organization of such materials for an animated film presentation. Touching on the evolution of animation technique, Mr. Kleidon described and cited examples of the important role now being played by the animation stand in providing movement to supplement and complement that created by the artist.

In a paper entitled "Use of the Animation Stand with Still Photography," Edward G. Willette of The Animation Equipment Co., New Rochelle, N.Y., described the use of an animation stand in creating a film from material other than the conventional painted cels. To illustrate this paper, the speaker screened the well-known *City of Gold* produced by the National Film Board of Canada. This film, which tells the story of the gold rush in the Yukon Territory and the settling of Dawson City, was made almost entirely from old still photographs taken at that time. Through the creative application of animation techniques, the still photographs were virtually brought to life. In a second demonstration film, screen examples showed what effect different movements on the animation stand would yield on the final film.

A question and answer period followed the formal presentation by Mr. Kleidon and Mr. Willette and samples of animation materials were available for inspection. John Colburn Associates hosted a coffee hour which closed the meeting.—William H. Smith, *Secretary-Treasurer*, Lakeside Lab., Box 2408, Gary 5, Ind.

The Nashville Section met on January 24 at WSM-TV in Nashville with an attendance of 10. W. M. Holder of Noble-Dury & Associates discussed "Video tape vs. Film."

In connection with his agency's work, Mr. Holder had made a survey of all stations using Ampex Videotape Recorders. The results of this survey were reported and technical information relative to the quality of equipment, materials and methods used in operating, was given. At the close of

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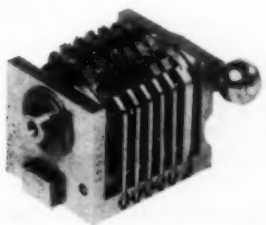

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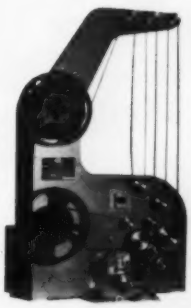

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his formal presentation, the speaker answered questions, most of which were concerned with the costs and savings of tape production as compared with film.

The balance of the program included a film, produced by the Television, Radio and Film Commission (Methodist Church), which utilized special sets and production techniques, and some experimental film using new animation techniques presented by Joe Zinaman of Zinn Animation Studios, Nashville. Coffee and doughnuts were served by WSM-TV.—Frank M. McGeary, *Secretary-Treasurer*, Motion Picture Laboratories, Inc., 781 S. Main St., Memphis 6, Tenn.

The Nashville Section met on May 19 at the Vanderbilt University Theatre in Nashville with an attendance of 56. Gatha F. Cottee, Assistant Chief to the Range Photo Officer, Patrick Air Force Base, Fla., guest speaker, discussed "The Use of Photography in Missile Training."

Mr. Cottee's interesting report on the activities of the various photographic units that take part in missile photography at Cape Canaveral was illustrated with color slides. A series of film clips, taken from a large number of missile firings, made a spectacular showing at the conclusion of his formal presentation. A question and answer period followed.

The enthusiastic audience included members of other engineering societies who had been invited to attend the meeting.—Frank M. McGeary, *Secretary Treasurer*, Motion Picture Laboratories, Inc., 781 S. Main St., Memphis 6, Tenn.

New Members

The next *Directory for Members* is planned for April 1960. The following members have been added to the Society's rolls since the list published in April 1959. Also listed are those regretfully reported as deceased since that date. The designations of grades are the same as those used in the *Directory*. An up-to-date list of the Sustaining Members appears on the outside back cover of each month's *Journal*.

Fellow (F) Active (M) Associate (A) Student (S)

Deceased

W. G. Millais (M)
A. J. Moran (A)
W. J. Morlock (M)
M. G. Sinkevitch (A)

Adamson, Hubert D., TV Cameraman, WSB-TV. Mail: 469 Hascall Rd., N. W., Atlanta 9, Ga. (A)
Anderson, Attell B., Research & Devel. Eng., Bell Telephone Labs., Whippany N. J. (M)
Appleton, Frederick J., Dir. Sound Recording, Artransa Pty. Ltd. Mail: 38 Rowena Rd., Dee Why West, N.S.W., Australia. (M)
Arthur, Garfield M., Chief Elect. Eng., Fitchburg Engineering Corp. Mail: 15 Warren St., Fitchburg, Mass. (M)
Aspajo, Luis A. Reategui, Cameraman, Estudios Cinematog. Rosello. Mail: Avda. Peru 847, Dpto. 311, Brena, Lima, Peru. (A)

Bagdasarian, Alex, Lab. Mgr., Rockwell Films Inc., 26 Church St., Harvard Square, Cambridge, Mass. (M)
Baker, Blaine, Manager, Versatile TV Prod., Inc. Mail: 2642 Marvin St., Cape Girardeau, Mo. (M)
Barber, J. Oscar, Production Mgr., Rainbow Pictures. Mail: 1211 N. E. 153 St., North Miami Beach, Fla. (M)
Bardes, Harold, Pres., Bardes Photography, Inc. Mail: 1222 Summit Ave., Union City, N. J. (M)
Barnhart, William, Video Devel. Eng., Ampex Corp. Mail: 4237 Park Blvd., Palo Alto, Calif. (M)
Basheer, Ahmed, Mot.Pic. Prod., Govt. of Pakistan. Mail: UCC Building #2, Lawrence Rd., Ramswami Karachi 3, Pakistan. (A)
Baumgardt, Mars F., Univ. So. Calif. Mail: 5501 Calle de Ricardo, Torrance, Calif. (S)
Becker, Alfred, Chief Eng., Scottish TV. Mail: 89 Fernleigh Rd., Glasgow S3, Scotland. (A)
Bell, Jerry, Prod. Supvr., Stage Dir., Century Lighting Inc., Box 775, N. Miami 61, Fla. (A)
Bender, Werner K., Dir., Kalart Company. Mail: 61 Beechwood Rd., West Hartford 7, Conn. (M)
Berenguer, Manuel, Cinematog. Mail: Zumaya, 3 La Florida-Urvacesa, Madrid, Spain. (A)
Bernstein, Julian L., Instructor, RCA Institutes, Inc. Mail: 67-36 214th St., Bayside 64, N. Y. (M)
Bessire, Jean-Jacques, Managing Dir., Perfectone Bienne. Mail: 30 Pierre Grise, Bienne, Switzerland. (A)
Blackwell, Samuel E., Mot.-Pic. Photo., Chrysler Corp., Missile Div. Mail: 36140 Woodingham Dr., Mt. Clemens, Mich. (M)
Bonner, John A., Sound Techn., 20th Century-Fox. Mail: 2830 Glendon Ave., Los Angeles 64. (A)
Briller, Harold H., Photo. Eng., U.S. Army Signal Equip. Support Agy., Ft. Monmouth. Mail: 25 New Monmouth Rd., Middletown, N. J. (M)
Brown, Robert M., TV Eng., Columbia Broadcasting System. Mail: 12134 Valley Spring La., N. Hollywood, Calif. (M)
Bulkley, Edward O., Electronic Eng., Westrex Corp. Mail: 1802 Euclid Ave., San Marino, Calif. (M)
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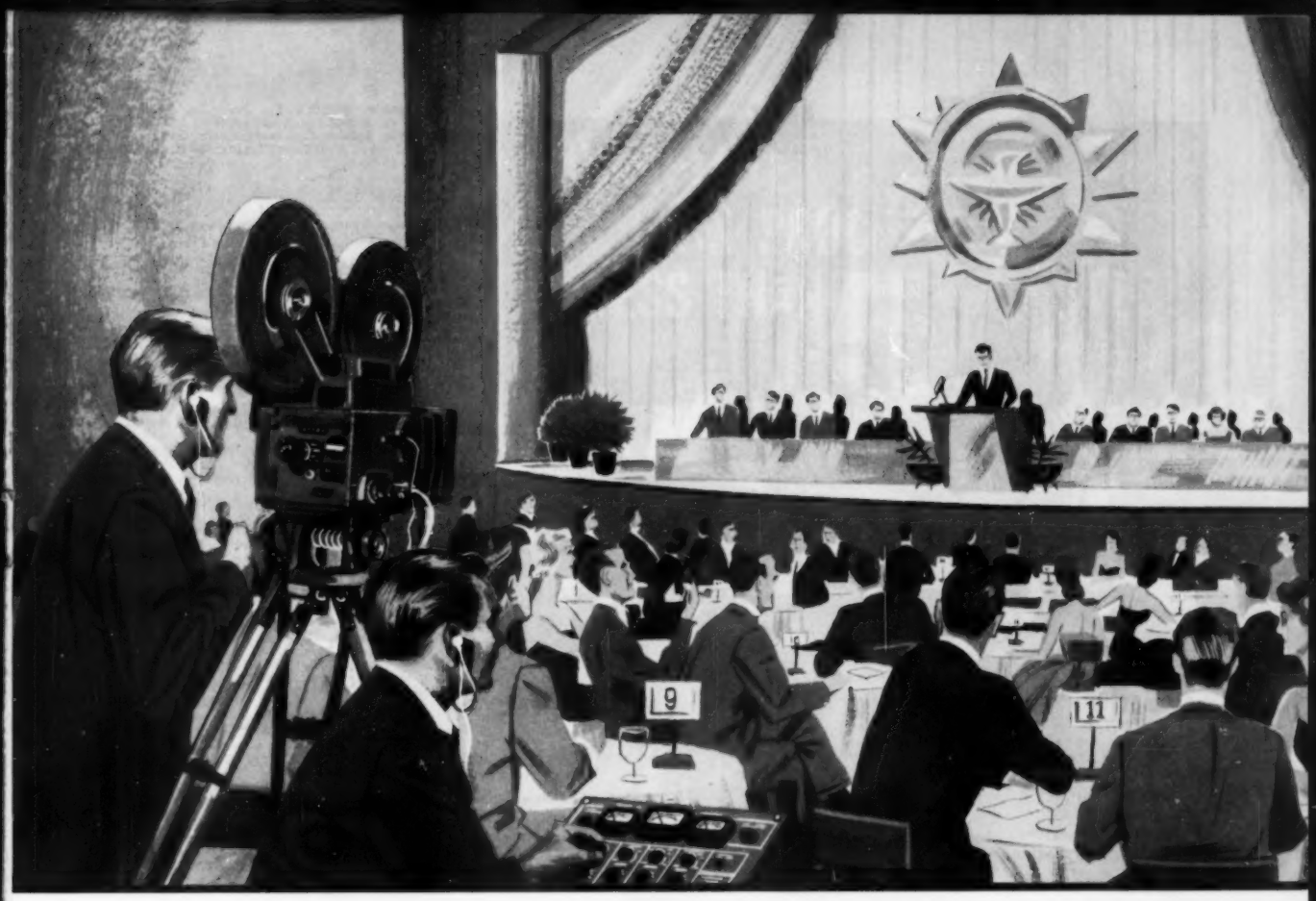

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Fain, Joe W., Newsreel Cameraman, WSB-TV. Mail: 159 Hedges St., Marietta, Ga. (M)
Fay, James P., Vice-Pres., Teletrak Systems Inc. Mail: 119 Ward St., Norwalk, Conn. (M)
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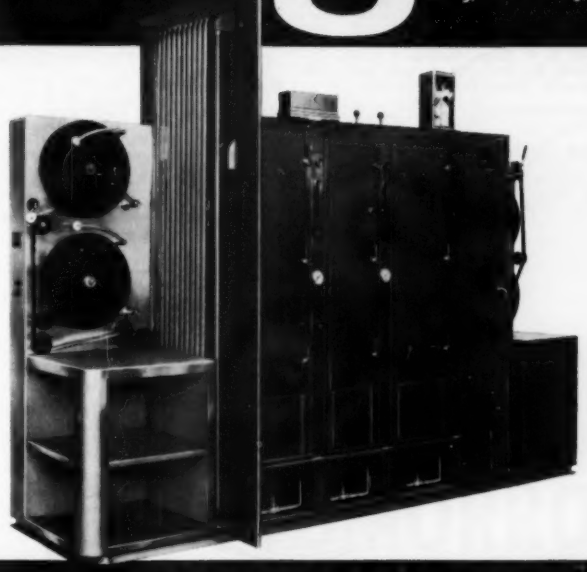

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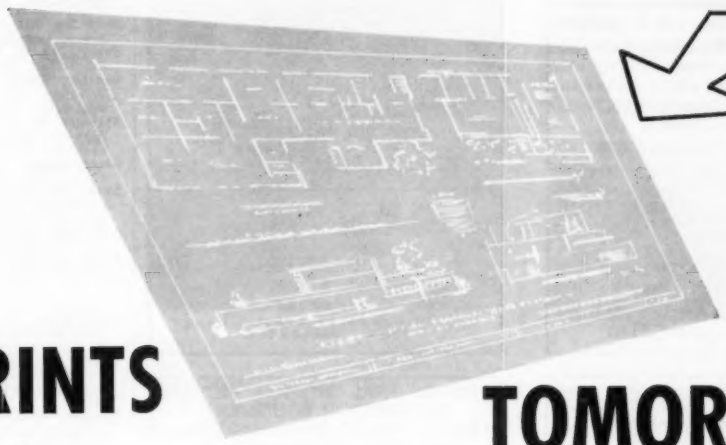

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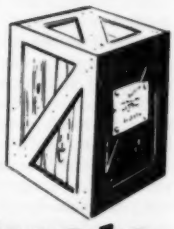


new products

(and developments)

Further information about these items can be obtained direct from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of these items does not constitute endorsement of the products or services.

A new 16mm picture and sound printer will be presented by JM Developments, Inc., 116-118 West 29 St., New York 1, as part of the apparatus exhibit at the Fall Convention in October. The printer has been designed by John A. Maurer.

The picture head is of the continuous type. The printing sprocket is driven by a mechanical filtering system, with speed constancy comparable to that of a good sound recorder. This makes it possible to use a narrow printing aperture projected optically on the film to avoid the possibility of dust accumulation. The films are controlled by tension arms and idlers in such a way that the slippage which must occur whenever two films are carried around a sprocket is made to occur only when the frame line is being printed. It is claimed that these features result in unusually sharp and steady prints.

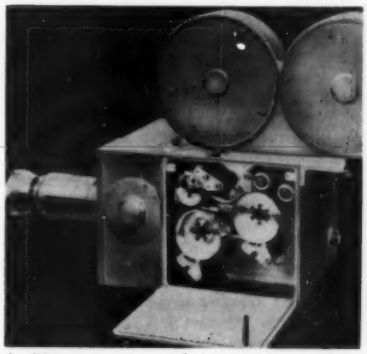
The illuminating and light control systems for picture printing are arranged for additive color printing with individual scene compensation for departures from normal color balance. A 30-point light scale is controlled by standard 8-place punched paper tape, which also controls the color-balance changes. The tricolor filter assembly is removed when the machine is to be used for black-and-white printing.

Photographic soundtracks are printed either by re-recording from magnetic originals or by optical printing at one-to-one ratio from photographic sound negatives. The re-recording optical system uses a galvanometer tuned to 26,000 cycles to provide flat transfer of recorded frequencies up to 8000 cycles at a printing speed of 120 ft/min. The track is of the variable-density linear type, which has high playback level as well as freedom from both nonlinear and cross-modulation distortion. By simple insertion of the proper recording control masks and filters, the system is made suitable for recording on either black-and-white positive stock or color print stock.

The optical system for one-to-one ratio sound printing uses a newly designed lens train to provide maximum high-frequency response. In this method of printing, the negative and positive films are driven independently by high-quality constant-speed mechanisms. Flutter introduced by printing is less than 0.05%. The irregularities of high-frequency response that always result from slippage on a contact printer are avoided.

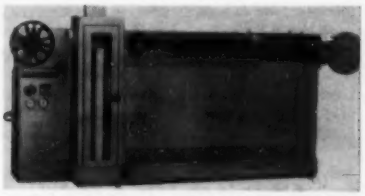
Simple threading paths are presented for the printing of either single-system or double-system originals with either magnetic or photographic soundtracks.

An immediate application of importance to the television industry is the making of high-quality prints with photographic tracks from negatives of newsreel subjects photographed and recorded on prestriped film.



A 70mm rotary prism camera with a reported speed of up to 360 frames/sec has been announced by Traid Corp., 17136 Ventura Blvd., Encino, Calif. Employing the same prism-shutter combination used in the 16mm-1B and 35mm-4B cameras, the new camera, called the Photo-Sonics 70mm-10B, is especially applicable to situations where long-range viewing is required, for example, in seat-ejection tests, where photographers are usually not allowed within 2000 ft of the track. The camera's design makes it useful for missile photography and high-resolution streak photography.

A transistorized power amplifier-speaker combination, Model MR-1A has been announced by Hallen Electronics, 332 N. LaBrea Ave., Los Angeles 36. The 12-w, transistorized amplifier is said to be acoustically flat and free from dips and peaks in frequency response from 40 c to 12,000 c. Volume and equalization controls are provided on a recessed panel and a jack is provided for an external speaker. The combination was originally designed as a companion to the company's 1216 Magnetic Film Recorder.



A lightweight (500 lb) 16mm daylight reversal negative/positive processor designed for fast processing and ease of installation and maintenance has been announced by Filmline Corp., Milford, Conn.

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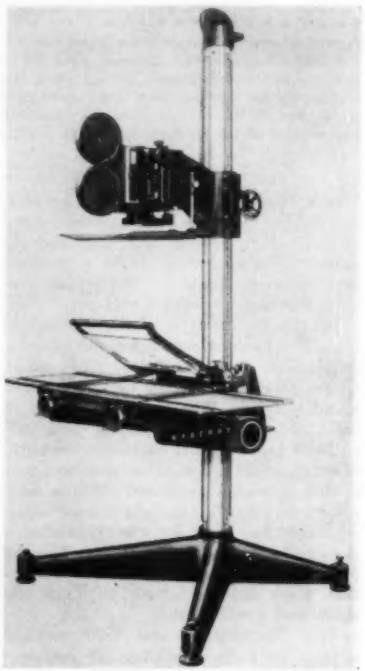
The new processor, Model RT-S, is recommended for racetracks, laboratories and TV stations where fast processing is essential. A dry-to-dry time of less than 3 min on reversal emulsions operating at 85 ft/min at a temperature of 90 F has been reported. The unit includes a variable-speed transmission and impingement drying system to permit processing speeds up to 55 ft/min on negative and 125 ft/min on reversal emulsions. The machine is reported to allow an increase of the ASA index by 1000% on Eastman or Du Pont reversal films. Installation requires only water inlet, water and chemical drains, and electrical hookups. Approximate dimensions are: length, 7 ft, 8 in.; width, 2 ft, 8 in.; and height, 3 ft, 11 in. The machine operates on 220 v, 60 c; single-phase, 25 amp. It is priced at $6450.

A new line of solid-state d-c amplifiers with transistor choppers has been announced by Packard Bell Computer Corp., 1905 S. Armacost Ave., Los Angeles 25. Designed to meet a need for wideband, extremely accurate amplification, the amplifiers employ solid-state circuitry throughout, including the chopper. The line includes wideband differential, operational and potentiometric amplifiers.

An automatic volume control amplifier reported to maintain a constant output within ±1 db with input changes of 30 db has been announced by Amplifier Corp. of America, 398 Broadway, New York 13. The amplifier basically consists of a two-stage push-pull circuit. The input may be connected either to a balanced 600-ohm line (with either or neither side grounded) or it may be bridged across a 600-ohm line without upsetting line impedance. An On-Off switch, a meter transfer and an attenuator are its only controls. An adjustable gain-reduction and gain-increase speed control permits variations in attack and release timing. It is equipped with a self-contained power supply designed for 110/220 v, 50/60 c with a power consumption of 30 w. It is 19 in. wide, 7 in. high and 8¾ in. deep and weighs 25 lb. It is priced at $245

An electronic data retrieval system called Telecard, which employs a device resembling a telephone dial and a closed-circuit TV system to display selected information, has been developed by General Precision Laboratory, Inc., Pleasantville, N. Y. Agreements to manufacture and market the system have been announced by GPL and the Filmsort Co., Pearl River, N.Y., division of Miehle-Goss-Dexter, Inc. Dialing a code number electronically activates the system to select the desired file card out of thousands — or millions. The system can also be activated by punched cards or magnetic tape. Closed-circuit TV is incorporated to transmit an image of the dialed record to the viewer's desk. The documents can be viewed simultaneously by any number of persons at various locations.

A Slip-Sync System designed for use in studies of vibration tests and a small, high-intensity stroboscopic lamp and power unit called Strobex are described in separate brochures issued by the manufacturer, Chadwick-Helmuth Co., 472 E. Duarte Rd., Monrovia, Calif. The brochures are illustrated and include specifications, detailed descriptions and suggested applications for each unit. A third brochure, issued by the same company, describes the Camera-Sync System, a system designed to produce slow-motion pictures of vibration tests, using normal film speeds. The system employs stroboscopic illumination and a pulse camera, both synchronized with the vibration.



The Oxberry Unistand, designed with a single column and precision keys for vertical or horizontal mounting, has been announced by Animation Equipment Corp., 38 Hudson St., New Rochelle, N.Y. The design of the new unit emphasizes economy and accuracy. It is recommended by the manufacturers for educational institutions, industrial organizations, film strip and title studios and other organizations where initial economy is an important consideration. The copyboard carriage is designed to accommodate animation compounds, plain copyboards, light boxes, vacuum backs and easels. Such devices are interchangeably mounted on two cast aluminum side arms attached to a heavy cross tube. The tube is supported by the main carriage casting which rides the column on ball bearings. A handwheel, geared to the rack on the column, is used to position the copyboard carriage.

The basic stand consists of a single column, 4 in. in diameter and 86 in. long. Two precision steel keys and full-length rack are mounted on the column to guide the camera and copyboard carriages. The unit is available as a wall-mounted, pedestal or horizontal model. The wall-mounted model is priced at $1295, a price which does not include compound, camera, shadowboard or lights.

Interchangeability of video-tape records made in the United States, Great Britain or Continental Europe was the object of the development of a standards converter by Granada TV Network, Ltd., Granada House, Water St., Manchester 3, England. The Granada system has certain similarities to that used by the B.B.C. to convert the 625-line Eurovision standard to the 405-line British standard, but special problems were encountered in conversion to and from the 525-line American standard. The main problem was that of the beat or flicker occurring at the rate of 10/sec, representing the difference between the field rates of the two systems. A solution was found by applying a correcting 10-cycle waveform to the display so as to change the gain of the amplifier in the monitor at the flicker frequency, and in accordance with the law of combined image-orthicon storage and display monitor decay characteristics.

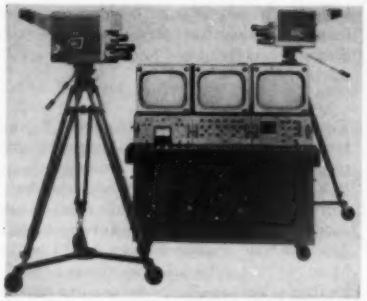
Conditions necessary for generating the correcting waveform are (1) frequency division (by 6 or 5) and subsequent multiplication (by 5 or 6) to ensure accurate and integral field-frequency relationship; (2) a phasing system to adjust the relative phases of 50- and 60-field signals to coincide during the frame blanking period every $\frac{1}{10}$ sec; and (3) generation of a correcting waveform and its application as a gain controlling parameter to the video amplifier within the display monitor.

The equipment is run from an a-c power supply of a frequency equal to that of the respective field rates. A synchronous 50-c motor is run from the local 230-v, 50-c power supply. The motor is gear-coupled to an alternator through a 6 to 5 ratio so that the alternator will invariably deliver a frequency which is 6/5 that of the local power supply. For example, if the local power supply is a cycle slow because of heavy loading, the alternator will deliver $6 \times 49/5$ cycles and not exactly 60. Electronic circuits permit control over the gamma of the displayed signal, allowing some correction to the overall transfer characteristic of the conversion process.

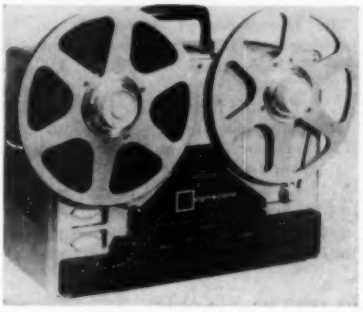
All circuits are embodied in a relatively small unit of equipment which has a cathode-ray-tube display of the phase of the 50-c and 60-c waveforms, or the shape of the correcting 10-c waveform.

A 110° cathode-ray tube, Type 23BP4, with the safety panel sealed to the tube by epoxy resin has been announced by Westinghouse Corp., Electronic Tube Div., P.O. Box 284, Elmira, N.Y. Double faceplate construction eliminates the implosion glass commonly used on TV receivers. Since the epoxy resin and the glass faceplates have the same index of refraction, two reflecting surfaces are eliminated. The laminated panel is said to prevent accidental implosion and make the picture tube safer to handle.

A new tube for television cameras, the RCA-7513, has been announced by Radio Corp. of America. Used for both color and black-and-white, the new tube is constructed to ensure accurate alignment of each section of the tube with respect to the tube axis. When used with color cameras, the use of deflecting yokes and focusing coils is recommended.



Development of a completely mobile educational closed-circuit TV system, Model ETS-1, which can be moved from classroom to classroom "as easily as a tea cart" has been announced by Dage Television, a division of Thompson Ramo Wooldridge, Inc., Michigan City, Ind. Included in the system is a Dage 700-line resolution TV camera with viewfinder, hood and rear-controlled four-lens turret. The mobile console, which includes video monitors, camera control, sync generator, power supply and waveform monitor, is designed to fit in a panel truck, and to go through a standard, 30-in. doorway. Additional equipment can be added as needed. Cameras, film projector controls, audio switching and mixing, video switching and fading, and a spare transistorized sync generator can be added without impairing mobility. Prices of the new system, including cameras and basic equipment, begin at about $11,800.



A new tape recorder, the Magnecord Model 728 Professional, has been announced by Magnecord Division of Midwestern Instruments, Inc., 41st and Sheridan, Tulsa, Okla. Features include two-channel capacity, modular construction, flexibility of operation, low flutter and wow and extended frequency response. It is available with full-track, $\frac{1}{2}$-track or split stereophonic heads. A fourth head, ordinarily used to reproduce $\frac{1}{4}$-track stereophonic tapes may be mounted in the head bracket. The fourth head is not required for sound-on-sound operation. Without the fourth head, the recorder is priced at $759; with the additional head, $850.

A closed-circuit TV camera designed by Packard Bell Electronics Corp., 12333 W. Olympic Blvd., Los Angeles 64, is announced as providing detail in excess of 600-line resolution. It has single operating control, a fully regulated power supply, keyed automatic black-level control, and an automatic light compensator. Remote accessories, available for all applications,

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The Model G-803 Triple Program Equalizer, designed for magnetic recording and reproduction, has been announced by Magnasync Mfg. Co., 5546 Satsuma Ave., North Hollywood, Calif. All components except switches are sealed and encapsulated. The machine measures 19 in. by 3½ in. by 3½ in. It has 600-ohm impedance; 14-db insertion loss; −70 dbm minimum and +20 dbm maximum input level; high- and low-frequency controls and standard Western Electric hole spacing. It is priced at $395.

The German-made Steenbeck line of editing equipment is now distributed in the United States by Gaston Johnston Corp., 26-64 45 St., Long Island City 3, N.Y. The line includes 2-, 4- and 6-plate film editing machines for 16mm, 35mm and CinemaScope film, motorized rewinding tables and an editing machine, called Kobiton, designed especially for use in TV studios on 16mm or 35mm film. An illustrated catalogue describing the equipment in detail is available from the company.

A semiautomatic, 500-w slide projector, called the Headliner 710, has been announced by Bell & Howell, 7100 McCormick Rd., Chicago 45. The machine features an illuminated editing panel at the back of the projector housing for previewing slides before they are loaded into trays for projection. The panel may be used at the same time the slides are being projected so that while one tray of slides is being shown slides may be selected for another tray. The projector projects 2 by 2, bantam and super slides. The price, which includes a carrying case, is $69.95.

The Fogmaker Moleffect, announced by Mole-Richardson Co., 937 N. Sycamore Ave., Hollywood 38, is a compact, 9-lb unit that uses a special liquid called fog juice to create effects of fog, smoke, haze or mist. A cooler attachment, filled with dry ice, will cause the vapor produced by the fog juice to hug the ground. The handy little device can also clear the area of haze, perfume the air with deodorants and kill flying and crawling insects. Appropriate liquids — fog chaser, spice or mint deodorant, and insecticide — are available. The device operates on the principle of a teakettle, with a plunger pumping liquid into the heat chamber to produce puffs of vapor. It requires 115-v a-c or d-c, 8.3 amp, 1000 w, and is equipped with a 6-ft detachable cord. The basic unit is priced at $94.50.

Formation of a new company, Arriflex Corp. of America, 257 Park Ave. South, New York 10, has been announced by the company's President, Paul Klingenstein. Distribution of all Arri products, including film developing machines, has been transferred by Kling Photo Corp. to the new company. The transfer became effective July 1. Expansion of the Arri program and the specialized character of the equipment influenced the decision to create a new company.

Plans for installation of a Super High Frequency and Ultra High Frequency radio link between Birmingham and Norwich have been announced by Marconi's Wireless Telegraph Co., Chelmsford, Essex, England. The link will be twin-path and bi-directional and will cary B.B.C. television programs between the two cities, serving, en route, the new B.B.C. transmitter near Peterborough. The radio link in its final form will employ the Marconi 4000-mc equipments Type HM500 (terminal) and HM550 (repeater) together with the 2000-mc equipments Type HM200 (terminal) and HM250 (repeater). Such links are capable of carrying TV signals of 405 lines, 525 lines or 625 lines. Such links are also capable of carrying an NTSC-type color TV program and, by substitution of the necessary baseband amplifiers, they can be used to transmit 600 simultaneous telephone channels. Both the HM500/550 and the HM200/250 series of equipments use the English Electric Valve Co.'s traveling-wave tubes throughout.

Price reductions in 64-minute reels of "Scotch" brand video tape have been announced by Minnesota Mining and Mfg. Co., 900 Bush Ave., St. Paul 6, Minn. The net price also has been reduced to $260.27 in lots of 24 to 47 and to $271.58 in lots of 6 to 23.

Bulletin No. 7 in the series on Projector Carbons has been issued by National Carbon Co. Division of Union Carbide Corp., 30 E. 42 St., New York 17. The 8-page bulletin discusses mirror-type high-intensity lamps using Suprex carbons — nonrotating, positive. A number of illustrations add interest and clarity to the text.

Nameplate Designing for Engineers, a 20-page booklet published by H. G. Dietz Products Co., 12–16 Astoria Blvd., Long Island City 2, N.Y., is intended as a guide for engineers or draftsmen in designing or specifying nameplates for products in the development stage. Subjects discussed include lettering, composition, how to draw a rough nameplate layout, selection of materials, odd-shaped nameplates and other items of interest. The booklet is available without charge upon request to the company.

Audio-visual equipment manufactured by Genarco Inc., 97–04 Sutphin Blvd., Jamaica 35, N.Y., is illustrated and described in a 4-page catalog available without charge from the company. Among the equipment described is the Genarco 3000-w slide projector, available in various models, and electric slide changers for 3¼ by 4 slides.

Supplementary sheets for the Sylvania Photolamp Technical Manual have been issued by Sylvania Lighting Products, Div. of Sylvania Electric Products Inc., 1740 Broadway, New York 19. Sheets Nos. 890, 893, 894, 8101, 8102 and 8103 describe a new high-voltage Tru-Focus lamp and a new low-voltage Super Tru-Flector. Sheet 891 replaces present sheet 7319 in the Projection Lamp section and sheet 892 replaces 825.

Lens Selector, an illustrated four-page folder issued by Traid Corp., 17136 Ventura Blvd., Encino, Calif., describes more than 57 different lenses for motion-picture cameras which are available on a rental basis. Covering a wide range of wide-angle, normal, and long focal length and zoom lenses for 16mm and 35mm cameras, the folder also includes information on lenses for 70mm and prism cameras. The folder is available without charge upon request to the company. It is a companion publication to *Camera Selector* (*Jour.* p. 370, May 1959).

These notices are published for the service of the membership and the field. They are inserted three months, at no charge to the member. The Society's address cannot be used for replies.

Positions Wanted

Motion-Picture or Television Production. Graduate New York Univ., B.A. Communication Arts. Experienced all phases motion-picture and television production. Seeking permanent position with television or motion-picture production organization. Willing to relocate. Résumé on request. Write: Walter Bleich, 2700 Marion Ave., New York 58.

Assistant to Director or Producer. Former instructor in motion pictures, Theater Arts Dept., Univ. of California, Los Angeles, desires position as personal assistant to a director or producer of feature films. Background includes: B.A. in Motion Pictures, 3 years teaching all phases of motion-picture production, second unit direction of a Disney "true-life adventure," and director of photography on dramatic and documentary films. Willing to travel. Available for interview in Los Angeles area. For references and detailed résumé write: William R. Lieb, 140½ W. Foothill Blvd., Claremont, Calif. Tel: NAtional 4-4166.

Editor-Cameraman. Over 10 yrs solid production experience in New York with quality producers of industrial, business and television films. Seek staff position. Résumé available. Member SMPTE since 1948. No other affiliations. Joe M. Wolff, 43-31 Ithaca St., Elmhurst, N.Y.

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Motion Picture Cameraman. Active member SMPTE now employed at local film studio. Formerly with Telenews and CBS-Newsfilm. Just completed study in film production in the States with M.S. degree. Owner of 16mm Bell & Howell and 35mm Arriflex cameras. Desire film assignments in Formosa and neighboring countries—16/35, color/B&W, news, documentary, educational and production work. Write: Dennis K. Chin, P. O. Box 222, Taipei, Taiwan.

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Chief Engineer. Immediate opening. Responsibilities include the administration of a staff of engineers designing electro-mechanical products for commercial and military application. Located in the Los Angeles area. Please reply in writing to W. C. Heath Associates, Inc., Room 526, 714 West Olympic Blvd., Los Angeles 15, Calif.

Audio Repair Man. Thoroughly experienced on magnetic tape recorders, projector and Moviola amplifiers, etc. Knowledge of motion-picture sound equipment essential. Good salary. Write fully to Arthur Florman, Florman & Babb, Inc., 68 West 45 St., New York 36.

Motion-Picture Equipment Salesman. Knowledge of all professional production equipment. Outside sales, to visit film producers, industrial accounts, etc. Fully exerienced. Good salary. Write fully to Arthur Florman, Florman & Babb, Inc., 68 West 45 St., New York 36.

Recording Engineer. To serve as head of electroacoustics laboratory involving duties in the fields of audio-video, acoustics and recording systems. Must be able to render consultation services in connection with research and development on related electronic systems and programs. Degree plus 3 yrs professional experience in above fields required. Salary $8810 per annum. Position is in Federal Career Service. Send SF-57 "Application for Federal Employment," obtainable at any Post Office, to Employment Superintendent, U. S. Naval Training Device Center, Port Washington, N.Y.

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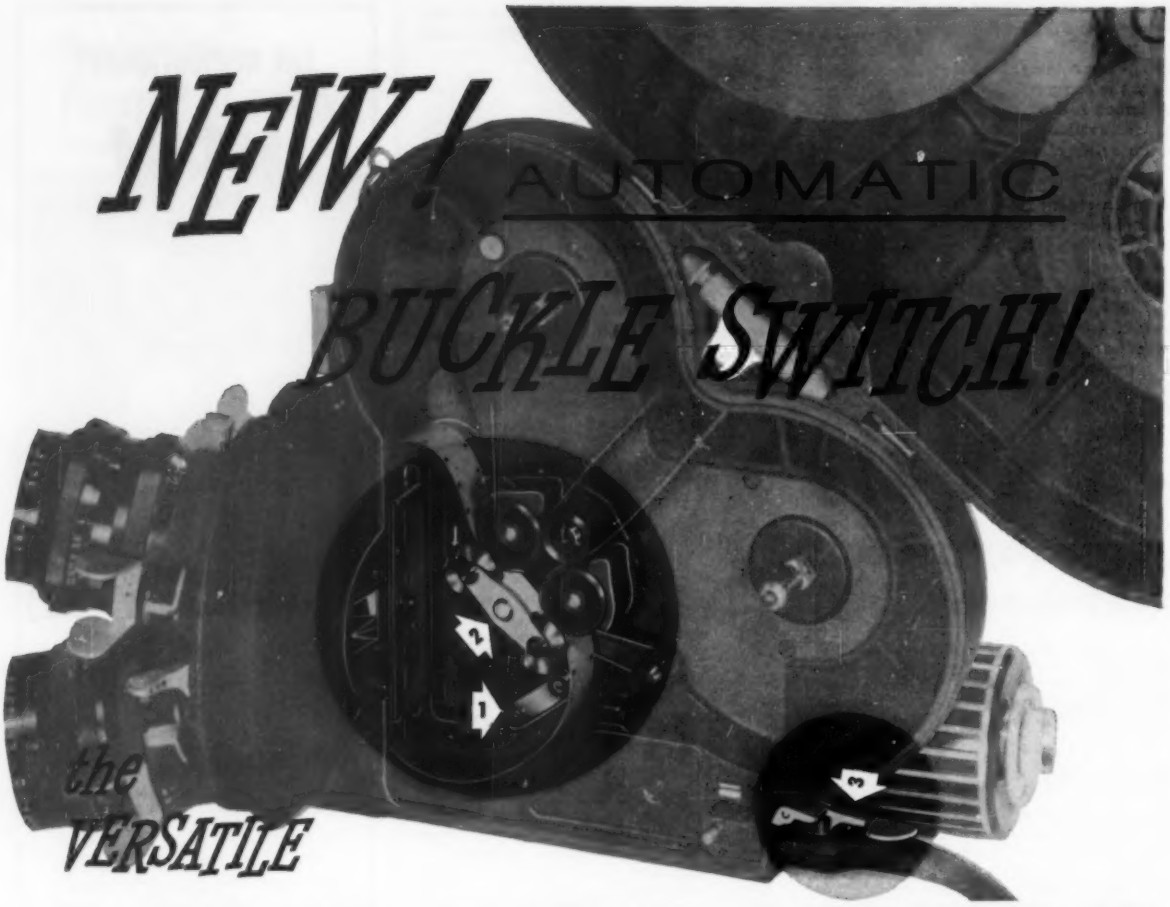

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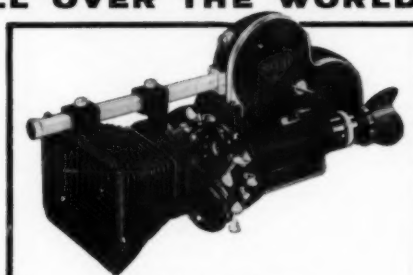

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Meeting Calendar

WESCON, Aug. 18–21, Cow Palace, San Francisco.
AIEE, Petroleum Industry Conference, Aug. 25–27, Wilton Hotel, Long Beach, Calif.
Mathematical Association of America, Summer Meeting, Aug. 31–Sept. 3, Univ. of Utah, Salt Lake City, Utah.
New York State Society of Professional Engineers, Autumn Meeting, September, Niagara Falls, N. Y.
Illuminating Engineering Society, Annual National Conference, Sept. 7–11, Fairmont & Mark Hopkins Hotels, San Francisco.
American Institute of Electrical Engineers and National Electrical Manufacturers Association, National Electrical Insulation Conference, Sept. 9–11, Chicago, Ill.
Society of Plastics Industry, Midwest Section Conference, Sept. 10, 11, French Lick, Sheraton Hotel, French Lick, Ind.
American Chemical Society, National Meeting, Sept. 13–18, Atlantic City, N.J.
Standards Engineers Society, Annual Meeting, Sept. 21–23, Somerset Hotel, Boston, Mass.
Instrument Society of America, Annual Instrument-Automation Conference and Exhibit, Sept. 21–25, International Amphitheatre, Chicago, Ill.
IRE, Conference on Non-Linear Magnetics and Magnetic Amplifiers, Sept. 23–25, Shoreham Hotel, Washington, D.C.
AICE, Sept. 27–30, St. Paul Hotel, St. Paul, Minn.
National Symposium on Telemetering, Sept. 28–30, Civic Auditorium and Whitcomb Hotel, San Francisco.
IRE and AIEE, Industrial Electronics Conference, Sept. 30–Oct. 2, Muelbach Hotel, Kansas City, Mo.
11th International Cinematography Engineering Congress, Oct. 1–3, Turin.
IRE, Aeronautical Communications Symposium, Oct. 5–7, Hotel Utica, Utica, N. Y.
86th Semiannual Convention of the SMPTE including Equipment Exhibit, Oct. 5–9, Statler Hilton Hotel, New York.
IRE Canadian Convention, Oct. 7–9, Toronto, Ont.
Optical Society of America, Annual Meeting, Oct. 8–10, Chateau Laurier Hotel, Ottawa, Ont.
ASCE, Los Angeles Convention, Oct. 9–13, Hotel Statler, Los Angeles.
AIEE, Fall General Meeting, Oct. 11–16, Chicago.
National Electronics Conference, Oct. 12–14, Hotel Sherman, Chicago.
National Society of Professional Engineers, Fall Meeting, Oct. 15–17, Olympic Hotel, Seattle, Wash.
ASCE, Annual Convention, Oct. 19–23, Hotel Statler, Washington, D. C.
American Standards Association, National Conference on Standards, Oct. 20–22, Sheraton-Cadillac Hotel, Detroit, Mich.
Acoustical Society of America, Fall Meeting, Oct. 22–24, Wade Park Manor Hotel, Cleveland, Ohio.
Society of Photographic Scientists and Engineers, Oct. 26–30, Edgewater Beach Hotel, Chicago.
IRE, Electron Devices Meeting, Oct. 29–31, Shoreham Hotel, Washington, D. C.
Louisiana Polytechnic Institute, Instrumentation Conference, Nov. 5, 6, Ruston, La.
IRE, Instrumentation Conference, Nov. 9–11, Atlanta, Ga.
Sixth National Symposium on Reliability and Quality Control, Jan. 11–13, 1960, Statler Hilton Hotel, Washington, D.C.
IRE National Convention, Mar. 21–24, 1960, Coliseum and Waldorf-Astoria Hotel, New York.
Inter-Society Color Council, 29th Annual Meeting, Apr. 11, 12, 1960, Philadelphia Museum College of Art, Philadelphia.
87th Semiannual Convention of the SMPTE, May 1–7, 1960, Ambassador Hotel, Los Angeles.
88thSemiannual Convention of the SMPTE, and
Fifth International High-Speed Congress and Equipment Exhibit, Oct. 16–22, 1960, Sheraton-Park Hotel, Washington, D.C.
89th Semiannual Convention of the SMPTE, Spring, 1961, Royal York, Toronto.
90th Semiannual Convention of the SMPTE, Oct. 15–20, 1961, New York.

SMPTE Officers and Committees: The rosters of the Officers of the Society, its Sections, Subsections and Chapters, and of the Committee Chairmen and Members were published in the April 1958 Journal, Part II.

sustaining members

of the Society of Motion Picture and Television Engineers

The objectives of the Society are:

- Advance in the theory and practice of engineering in motion pictures, television and the allied arts and sciences;
- Standardization of equipment and practices employed therein;
- Maintenance of high professional standing among its members;
- Guidance of students and the attainment of high standards of education;
- Dissemination of scientific knowledge by publication.

Progress toward the attainment of these objectives is greatly aided by the financial support provided by the member companies listed below.

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The Society invites applications for Sustaining Membership from other interested companies. Information may be obtained from the Chairman of the Sustaining Membership Committee, Byron Roudabush, c/o Byron Motion Pictures, Inc., 1226 Wisconsin Ave., N.W., Washington 7, D.C.